



The World Leader in Vibrating Wire Technology

*48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603•448•1562
Fax: 603•448•3216
E-mail: geokon@geokon.com
<http://www.geokon.com>*

GK-604D

Inclinometer Readout

Application

User's Manual

No part of this instruction manual may be reproduced, by any means, without the written consent of Geokon, Inc.

The information contained herein is believed to be accurate and reliable. However, Geokon, Inc. assumes no responsibility for errors, omissions or misinterpretation. The information herein is subject to change without notification.

Copyright © 2013 by Geokon, Inc.
(Doc Rev C, 7/2013)

Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon, Inc. is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by Geokon, Inc. or any breach of any warranty by Geokon, Inc. shall not exceed the purchase price paid by the purchaser to Geokon, Inc. for the unit or units, or equipment directly affected by such breach. Under no circumstances will Geokon reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, Geokon, Inc. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

Table of Contents:

1. Introduction	1
1.1 Features	2
1.2 GK-604D Inclinator Readout Application	3
1.3 Before using the GK-604D Inclinator Readout	6
2. Installation and Operation.....	7
2.1 Initial Quick Start Sequence.....	7
2.2 Establishing Contact with the Remote Module.....	10
2.3 Installing the GK-604D IRA.....	12
2.3.1 Launching the GK-604D Installer.....	13
2.4 Starting the Inclinator Readout the first time	18
3. User Interface.....	23
3.1 Overview	23
3.2 Project Explorer.....	24
3.2.1 Context Menu.....	25
3.3 Application Menu	26
3.3.1 Live Readings.....	26
3.3.2 Edit Settings.....	29
3.3.3 Remote Connect with... ..	29
3.3.4 Terminal Window.....	30
3.3.5 About GK-604D	30
3.3.6 System Configuration	31
3.4 File Menu.....	39
3.4.1 Export Menu	39
3.4.2 Import Menu.....	41

3.4.3 View Data.....	45
3.3.4 Delete/Restore Menu.....	48
3.3.5 Exit.	49
4. Configuring Project Explorer Elements	50
4.1 Hole Configuration.....	51
4.2 Probe Configuration.....	52
4.3 Project Configuration	53
5. Files, Folders and Transferring Data	54
5.1 File Transfer	55
5.2 Backing up configurations	55
APPENDIX A. Inclinator Theory	56
A.1. Inclinator Theory	56
A.2 Conducting the survey	59
A.3 Checksums and “Face Errors” on Inclinator Probes.....	60
A.3.1 Effect of “Face Error” on reading accuracy.....	61
A.3.2 Measurement of “Face Error”	62
A.3.3 Setting of the “Face Error” to zero.....	62
A.3.4 Conclusion	63
APPENDIX B. Data File Format	64
B.1 Hole Data File Format	64
APPENDIX C. Text Reports	66
C.1 Raw Data Text Report.....	66
C.2 A-axis Profile Data Text Report	67
C.3 B-axis Profile Data Text Report	68
C.4 A-axis Deflection Data Text Report	69

C.5 B-axis Deflection Data Text Report	70
APPENDIX D. Remote Module Command Structure	72
APPENDIX E. Data Reduction Formulas.....	74
E.1. Deflection Calculation	74
E.2. Profile Calculation	76
E.3. GTILT Users	77
APPENDIX F. Technical Specifications	78
F.1. GK-604D Digital System Specifications	78
F.2. Analog Probe System Specifications	79
F.3. Field PC (GK-604-6) Specifications.....	80

Table of Figures:

Figure 1 - GK-604D Remote Module with attached cable.....	1
Figure 2 - Model 6000-2 Control Cable (top)	2
Figure 3 - Archer Field PC running GK-604D IRA	3
Figure 4 - 6000/6100 type probe.....	4
Figure 5 - GK-604-4 Interface	4
Figure 6 - GK-604-3 Reel System (shown with the Archer unit and carrying case).....	5
Figure 7 - Probe Settings Mismatch	8
Figure 8 - Initial Probe Settings	8
Figure 9- ActiveSync Window showing active connection.....	12
Figure 10 - Windows Mobile Device Center	13
Figure 11 - Windows Explorer window displaying HHD root folder.....	14
Figure 12 - Hand-held device root folder contents	14
Figure 13 - Installation CD or Folder Contents	15
Figure 14 - GK-604D Installer at root of HDD	16
Figure 15 - GK-604D Install Screen	16
Figure 16 - GK-604D IRA Icon in Start->Program.....	17
Figure 17 - Select Workspace Name.....	18
Figure 18 - Select Workspace Folder	19
Figure 19 - Workspace Exists	19
Figure 20 - Select Probe Library Name	20
Figure 21 - Select Probe Library Folder	21
Figure 22 - Probe Library Exists	21
Figure 23 - Probe Connection Problem Figure 24 - Empty Workspace and Probe Library	22
Figure 25 - User Interface	23

Figure 26 - Context Menu	25
Figure 27 - Application Menu.....	26
Figure 28 - Main Screen, probe connected.....	27
Figure 29 - Live Readings Screen.....	27
Figure 32 - Save File Screen	28
Figure 30 - Unsaved Data prompt.....	28
Figure 31 - Auto Increment Save	28
Figure 33 - Remote Connect with... ..	29
Figure 34 - Terminal Window	30
Figure 35 - About GK-604D Figure 36 – Remote Module Status	31
Figure 37 - System Configuration.....	32
Figure 38 - Stable Indication	33
Figure 39 - Unstable Indication.....	33
Figure 40 – Auto Record Enabled	35
Figure 41 - Auto Record Active	35
Figure 42 - Auto record paused, Dataset 2 selected.....	37
Figure 43 - File Menu Figure 44 - Export Menu	39
Figure 45- Export Data Window Figure 46 - Save Data File	40
Figure 47 - Export Path Selection Figure 48 - Probe Selection Window	41
Figure 49 - Import Menu Figure 50 - Select Hole Export File.....	42
Figure 51 - Select Project Export File Figure 52 - Select Probe Export File.....	43
Figure 53 - Select Probe Library Export File Figure 54 - Probe Library Switch after Import.....	44
Figure 55 - Select View Options Window Figure 56 - View Option List	45
Figure 57 - Menu Options for Reports Figure 58 - Raw Data Report.....	46
Figure 59 - Axis Profile Report Figure 60 - Axis Deflection Report	46
Figure 61 - Profile Plot Figure 62 - Profile Plot - Marker On	47

Figure 63 - Deflection Plot.....	48
Figure 64 - Delete / Restore Window Figure 65 - Hole Delete / Restore Window.....	49
Figure 66 - Hole General Settings.....	51
Figure 67 - Hole Parameters.....	51
Figure 68 - Probe General Settings.....	52
Figure 69 - Probe Coefficients	52
Figure 70 - Project Settings.....	53
Figure 71 - Inclinator Casing (end view).....	56
Figure 72 - Inclinator Probe.....	57
Figure 73 - Inclinator Survey Description	58
Figure 74 - Plot of Borehole Deflection	58

1. Introduction

The GK-604D is made up of two components:

- the Readout Unit, consisting of an Archer Field PC running the GK-604D Inclinator Readout Application (see Figure 3)
- the GK-604D Remote Module which is directly connected to the inclinometer probe and is housed in a weather-proof reel enclosure (see Figure 1)



Figure 1 - GK-604D Remote Module with attached cable

The two components communicate wirelessly using Bluetooth®, a reliable digital communications solution. This simplifies the handling of the system in the field as well as simplifying the transfer of data to your PC workstation for final analysis.

1.1 Features

Rugged, general purpose, reliable readout based on an Archer Field PC:

- all the benefits of a Windows compatible device (Windows file system, RS-232, USB and wireless connectivity)
- long battery life
- ease of use

Lightweight and simple Remote Module:

- lithium battery (8 + hours of continuous use)
- one button operation; automatic power down when Bluetooth connection is dropped or after several minutes of inactivity
- rugged
- reliable connection to standard inclinometer probes (Figure 4) is accomplished via model 6000-2 control cable which features a lightweight, polyurethane jacket and is less than 7 mm in diameter (see Figure 2). The control cable contains a central Kevlar® strand with a breaking strength of 150 kg



Figure 2 - Model 6000-2 Control Cable (top)

1.2 GK-604D Inclinometer Readout Application

The GK-604D Inclinometer Readout Application (GK-604D IRA) installs and runs on a ruggedized hand-held PC (Archer Field PC) (see Figure 3) and is designed to communicate via Bluetooth with Remote Modules connected to analog or digital probes (see Figure 4), both MEMS and force-balance type. For digital probes the Remote Module is fully contained within the reel as depicted by Figure 1.

For analog probes an interface unit, GK-604-4 (see Figure 5), connects directly to the probe (analog MEMS and force-balance type) and can be purchased as a separate unit or as part of the GK-604-3 reel system (see Figure 6).



Figure 3 - Archer Field PC running GK-604D IRA



Figure 4 - 6000/6100 type probe



Figure 5 - GK-604-4 Interface



Figure 6 - GK-604-3 Reel System (shown with the Archer unit and carrying case)

1.3 Before using the GK-604D Inclinometer Readout

The readout software runs as an application under Windows Mobile 6 operating system installed on an Archer Field PC.

- The user should familiarize themselves with the Field PC and the Windows Mobile OS.
- It is assumed in the instructions below that the user can launch applications from the Start button including File Explorer and the Bluetooth Settings manager.
- It is assumed that the user can tap the keyboard icon as needed and use the on-screen keyboard to enter text and numbers.

2. Installation and Operation

The steps described in section 2.1 are an attempt to guide the user through the process of launching the GK-604D IRA, connecting to the probe and taking a survey. If all parts of the GK-604D are purchased as a system, Geokon makes every effort to ensure that the system is completely set up and working before it leaves the factory. Other times, the user may already own the hand-held PC and are setting up their hardware and software for the very first time. The steps below attempt to cover all cases and refer the user to the appropriate section when more information is needed.

For those users that have purchased a complete GK-604D system, a workspace with the name of “GK604D” and a probe library called “ProbeLibrary” will have been pre-defined and the Archer unit will already be paired with the Remote Module. Note that the workspace and probe library names can be changed at any time or new ones can be created (see section 3.2.1). When purchasing a GK-604D system, sections 2.2 through 2.4 can possibly be skipped but a quick review is recommended.

2.1 Initial Quick Start Sequence

The following steps are a guide to the typical operation of the GK-604D and, if followed, should result in a successful “hole” survey being taken:

- A) If the Remote Module has been previously paired with the Archer unit, then press the button labeled “POWER ON (BLUETOOTH)”. A blue light will be on and blinking, signifying that the Remote Module is waiting to connect to the Archer unit.

If the Remote Module was purchased separately from the Archer unit then see section 2.2 (Establishing Contact with the Remote Module).

- B) Launch the GK-604D IRA by tapping on “Start” from the Archer main window, then tap “Programs”, then tap the GK-604D IRA icon. If the GK-604D Inclinator Readout Application has not been installed, please see section 2.3 (Installing the GK-604D IRA).



- C) After a few seconds, the blue light on the Remote Module should change to a steady state blue (lit but not flashing) and the Main Window will be displayed (see Figure 28).

If the window shown in Figure 17 is displayed instead of the Main Window, please refer to section 2.4, “Starting the Inclinator Readout the First Time”.

If the Main Window is not displayed but the window shown in Figure 7 is, then the probe has not been previously detected by the GK-604 IRA (digital systems only). In this case, tap “ok” and the probe will be added to the Probe Library and

the window shown in Figure 8 will be displayed. This allows an opportunity to give the new newly detected probe a user friendly name and description. See section 4.2, Probe Configuration for more information on probe settings. When satisfied with the settings, tap “Menu->Save” Settings to return to the Main Window (see Figure 28).

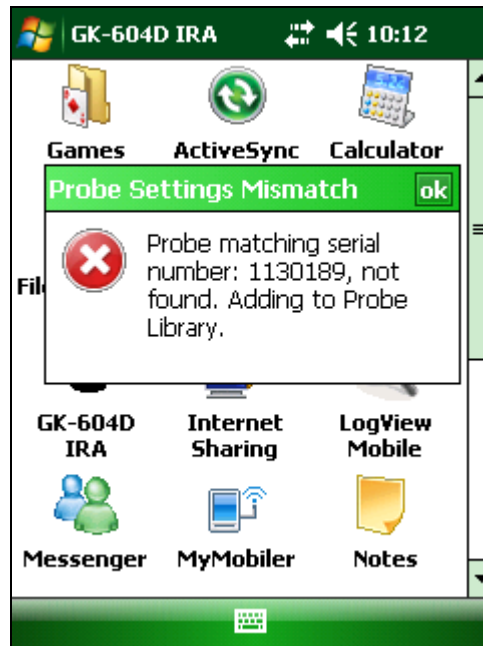


Figure 7 - Probe Settings Mismatch

General Probe Settings	
Probe ID:	PRB0311101724
Serial number:	1130189
Probe name:	
Description:	
Probe type:	Digital
Date created:	03/11/2013 10:17:24
Last edited:	

Navigation: Left Arrow, Right Arrow, Cancel, Menu

Figure 8 - Initial Probe Settings

- D) From the Main Window (see Figure 28), if the probe is connected and both a “hole” and a “probe” are selected (names displayed in the status area), then tap on the Application Menu (see section 3.3) then tap Live Readings. Refer to section 3.3.1 for more information about taking a survey using the Live Readings window. Also refer section A.2 for information regarding the mechanical process of taking a survey.

If a “hole” has not been defined or selected, please see section 4.1 for more information regarding hole configuration.

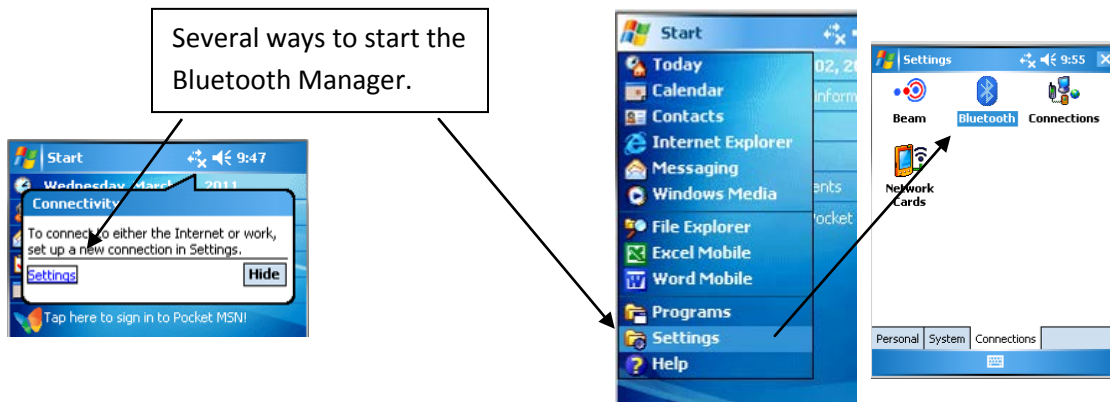
If a “probe” has not been defined or selected, please see section 4.2 for more information regarding probe configuration.

- E) After saving data corresponding to a particular hole survey reports may be reviewed and/or generated by tapping the “File” menu then “View Data”. See section 3.4.3 for more information about the View Data option.
- F) Raw data files may be exported to a file system folder of the user's choosing by tapping on “File”, then “Export”, then “Data”. See section 3.4.1.1 for more information regarding data export options.
- G) To close the GK-604D IRA, tap “File” then “Exit”.

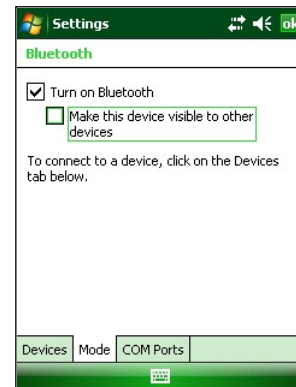
2.2 Establishing Contact with the Remote Module

In general this should only need to be done once and is typically done before it leaves the factory. Follow the steps below to ensure the 'partnership' with the remote is established before using the readout software:

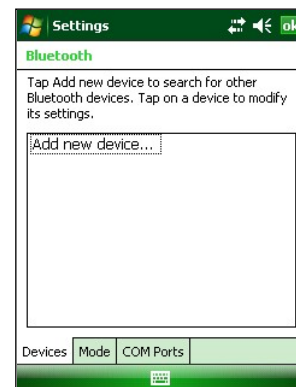
1. Use the Bluetooth Settings Manager on the Archer Field PC to set up the link to the remote. Read about setting up a Bluetooth "partnership" in Chapter 9 of the Field PC's Reference Guide.



2. Once in the Bluetooth Settings Manager, click on the "Mode" tab and then make sure that the box next to "Turn on Bluetooth" is checked.



3. Click on the "Devices" tab. If it shows a "Geokon" device (name will start with "GK" and contain the remote's serial number), go to the next step. Otherwise turn on the remote module (should see a flashing blue indicator on the remote) and select "Add new device...".



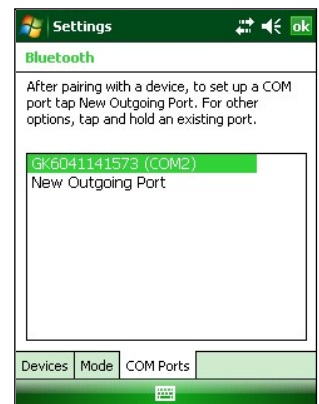
4. When a suitable remote is discovered, highlight the device and click Next.



5. A prompt will be displayed for a password; enter “default” and press Next again. If a partnership with the device is successfully established the screen will momentarily display the prompt to the right and then return to the Bluetooth Devices screen.



6. Click on the COM Ports tab. If the “Geokon” device is already assigned to a COM Port, the partnership process is finished. If not, select “New Outgoing Port” and select an available COM port (COM5 is the default). Be sure to remember the number of the COM port as you may have to select it later in the readout software (see section 3.3.3).



2.3 Installing the GK-604D IRA

The installation of the GK-604D IRA requires the following:

- Hand-held device (HHD) running Windows Mobile Classic 6.0 or higher with at least 50 Mbytes of free memory. HHD must be Bluetooth enabled and be able to assign a Bluetooth connection to a COM port. Windows .NET 3.5 Compact Framework (CF) and .NET framework English-language Messages package installed on HHD. Both “CAB” file installers are included in the GK-604D IRA installer “Zip” file, available on Geokon’s web-site (<http://www.geokon.com/digital-inclinometer-system/>) or via an installer CD.
- Microsoft ActiveSync version 4.5.0 or higher running on the host PC (see Figure 9) or Windows Mobile Device Center if PC is running Windows 7 (see Figure 10) as well as the HHD. An active connection between the two must be established either via a physical link or Bluetooth.

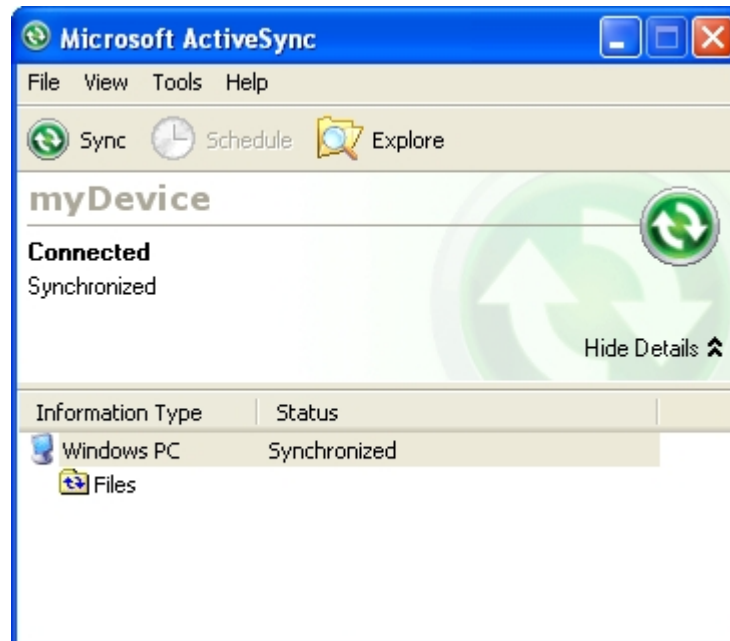


Figure 9- ActiveSync Window showing active connection



Figure 10 - Windows Mobile Device Center

2.3.1 Launching the GK-604D Installer

From the Windows Mobile Device Center window on the PC (see Figure 10) click on the folder icon labeled "Browse the contents of your device" to call up an Explorer Window for the HHD (see Figure 11). The procedure for ActiveSync is very similar.

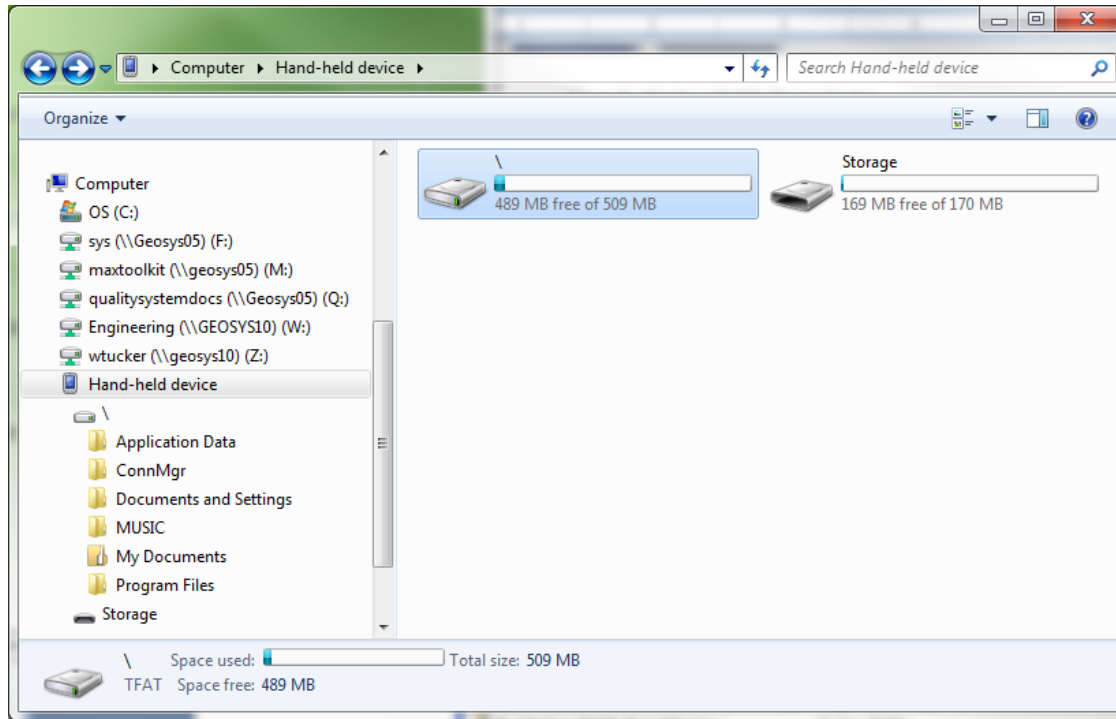


Figure 11 - Windows Explorer window displaying HHD root folder

In the Figure 11 above, double-click the icon labeled “\” to navigate to the hand-held PC’s system root shown in Figure 12.

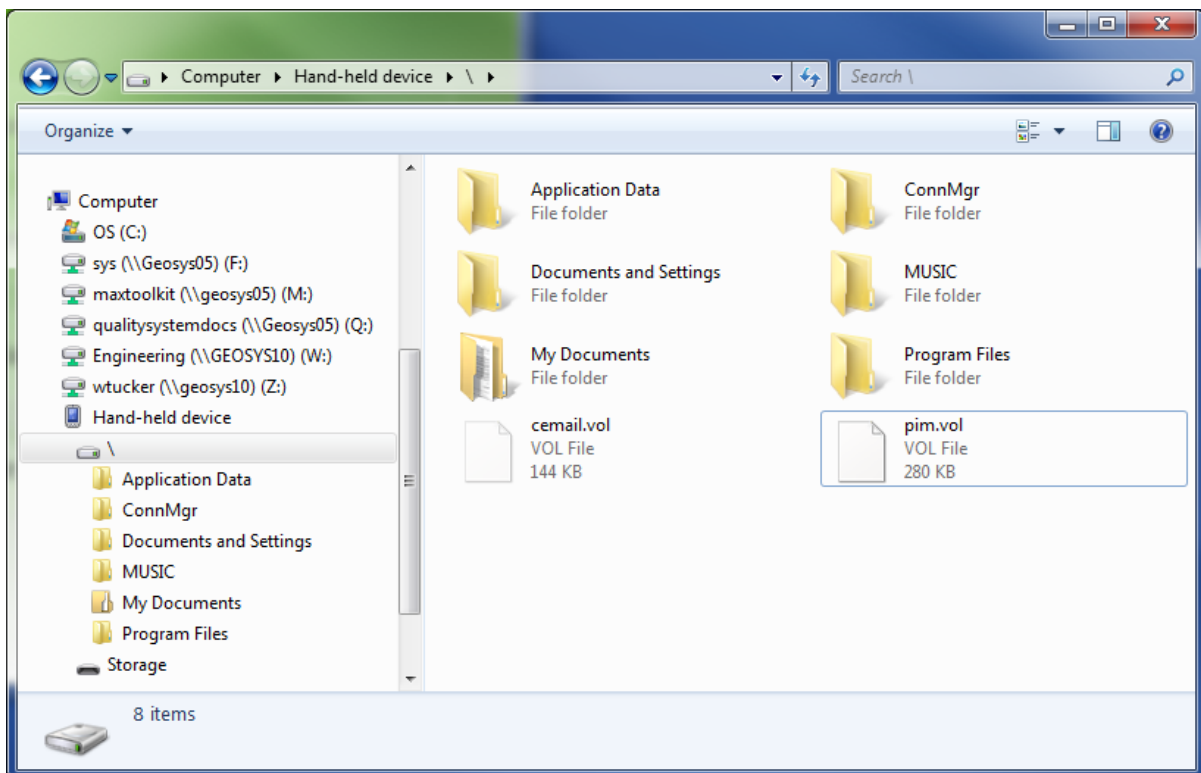


Figure 12 - Hand-held device root folder contents

Next, insert the GK-604D Installation CD into the PC's CD/DVD drive (or unzip the installer if downloaded from Geokon's web-site), open a Windows Explorer window and then navigate to the root folder of the Installation CD or folder (see Figure 13).

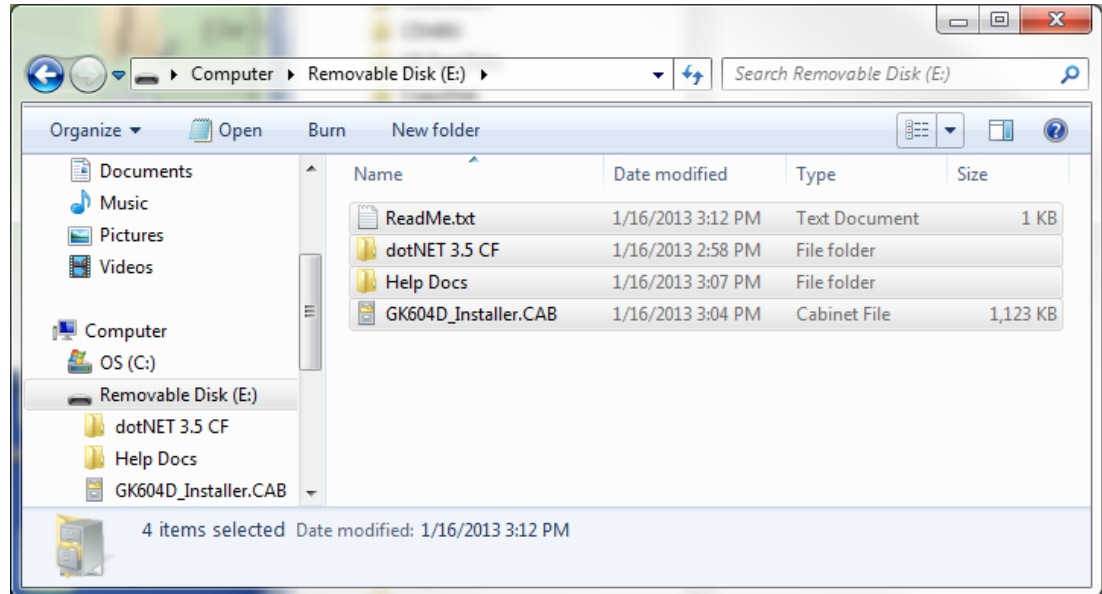


Figure 13 - Installation CD or Folder Contents

Copy the file, "GK604D_Installer.CAB" from the Installer CD to the HDD system root folder. From the HDD, navigate to the system root folder using File Explorer (see Figure 14) and tap the file, "GK604D_Installer" to execute the installer.

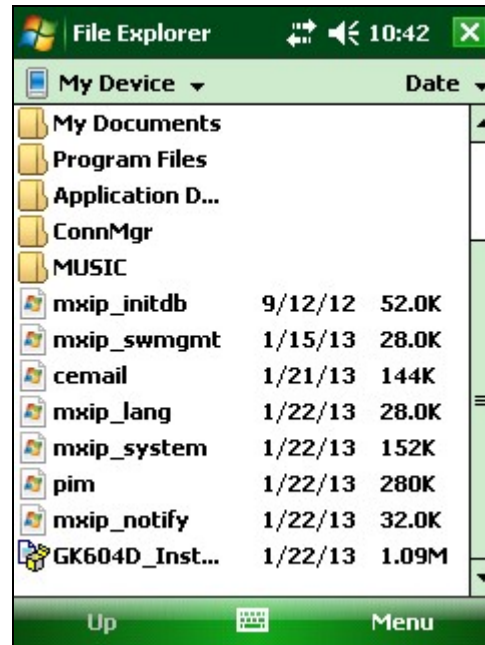


Figure 14 - GK-604D Installer at root of HDD

If there is a storage card installed in the HDD then the user will be prompted to choose the location for the installation (see Figure 15). It is recommended that "Device" be selected then tap "Install" with the stylus to initiate the install process.



Figure 15 - GK-604D Install Screen

The file, GK604D_Installer.CAB can be now deleted from the system root folder to free up memory. The GK-604D IRA is now installed and its icon should appear in “Start->Programs” (see Figure 16).

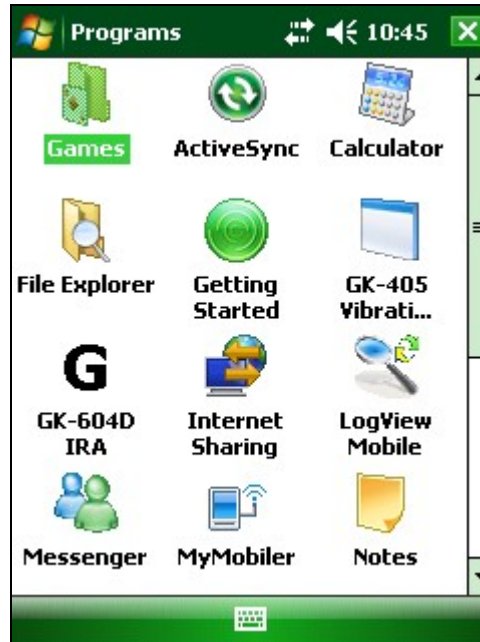
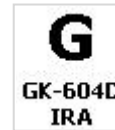


Figure 16 - GK-604D IRA Icon in Start->Program

2.4 Starting the Inclinator Readout the first time

The readout software is launched by tapping the Start button and selecting the icon (to the right) from the drop down list or clicking on Programs and then clicking the icon (to the right).



If the application fails to launch and the message, "This application requires a newer version of the Microsoft .NET Compact Framework than the version installed on this device", is displayed then the .NET Compact framework that is included in the installer "Zip" file should be installed. The .NET Compact Framework installer is called "NETCFv35.wm.arm4i.cab" and is located in a folder called "dotNET 3.5 CF" (see Figure 13). Installation is very similar to installing the GK-604D IRA. A companion package for the .NET Framework, "NETCFv35.Messages.EN.wm.cab", should also be installed at this time and is located in the same folder.

When starting the GK-604D Inclinator Readout Application (GK-604D IRA) for the first time, you will be prompted to create a workspace name. The workspace name can be any combination of letters and numbers and should be descriptive in nature. After creation, this name will be displayed in the Project Explorer window.

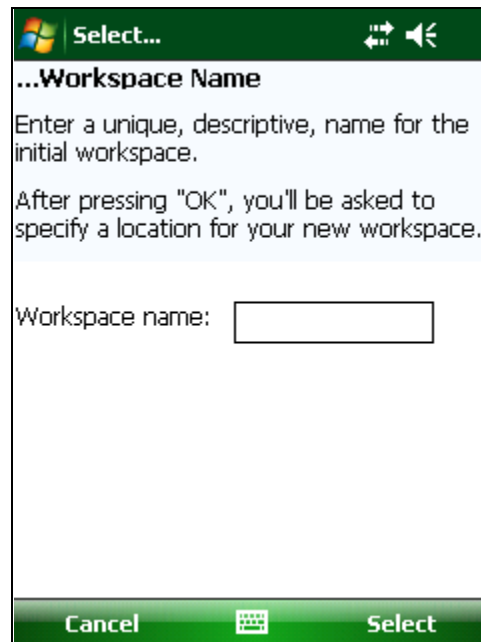


Figure 17 - Select Workspace Name

Once the name for your workspace is selected, you will be prompted to choose or create a folder on your PC where all the workspace elements will be stored. As can be seen below, the default workspace location is in a folder name the same as the workspace name under a special shared folder reserved for workspaces. For Windows Mobile devices, this folder is located at:

\Application Data\Geokon\GK-604D\Workspaces.

GK-604D IRA appends the name of the new workspace to this shared folder and uses it as the default location for the new workspace. The user is free to select their own location, either by entering it directly, or the **Browse [...]** button may be

used to navigate to a different folder location or to create a new folder (see Figure 18). This workspace location will be stored in the GK-604D IRA configuration for subsequent application access. After workspaces are created, all future user access to workspaces is always by name.

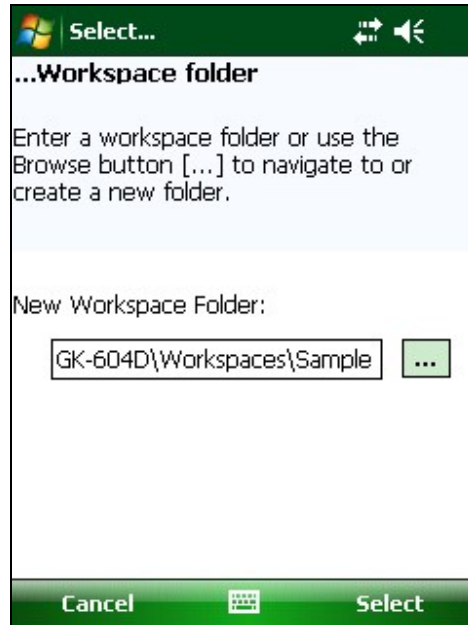


Figure 18 - Select Workspace Folder

 **Note:** If the newly selected workspace folder contains an existing workspace, GK-604D IRA will display a dialog prompt asking the user if they want to import the workspace as is or to rename it with the previously specified new workspace name.

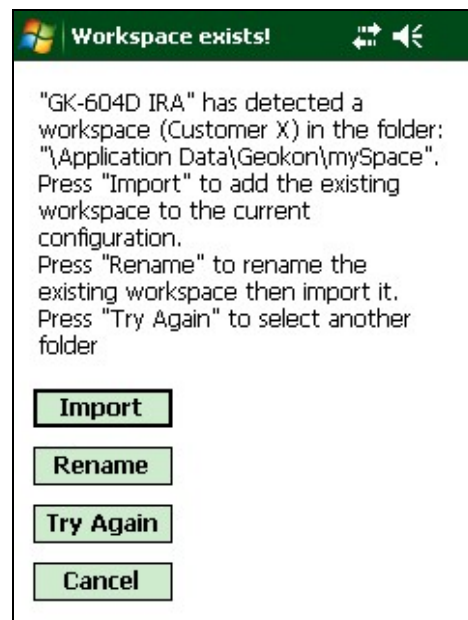


Figure 19 - Workspace Exists

Much like was done for the initial workspace, a probe library also needs to be created before the application can fully launch. After specifying the workspace folder, you will be prompted to create a probe library name. The probe library name can be any combination of letters and numbers and should be descriptive in nature. After creation, this name will be displayed in the Project Explorer window.



Figure 20 - Select Probe Library Name

Once you've selected the name for your probe library, you will be prompted to choose or create a folder on your PC where all the probe library elements will be stored. As can be seen below, the default probe library location is in a folder name the same as the probe library name under a special shared folder reserved for probe libraries. For Windows Mobile devices this folder is located at:

\Application Data\Geokon\GK-604D\Probe Libraries

GK-604D IRA appends the name of the new probe library to this shared folder and uses it as the default location for the new probe library. The user is free to select their own location, either by entering it directly, or the **Browse [...]** button may be used to navigate to a different folder location or to create a new folder (see Figure 21). This probe library location will be stored in the GK-604D IRA configuration for subsequent application access. After probe libraries are created, all future user access to probe libraries is always by name.



Figure 21 - Select Probe Library Folder

 **Note:** If the newly selected probe library folder contains an existing probe library, GK-604D IRA will display a dialog prompt asking the user if they want to import the probe library as is or to rename it with the previously specified new workspace name.

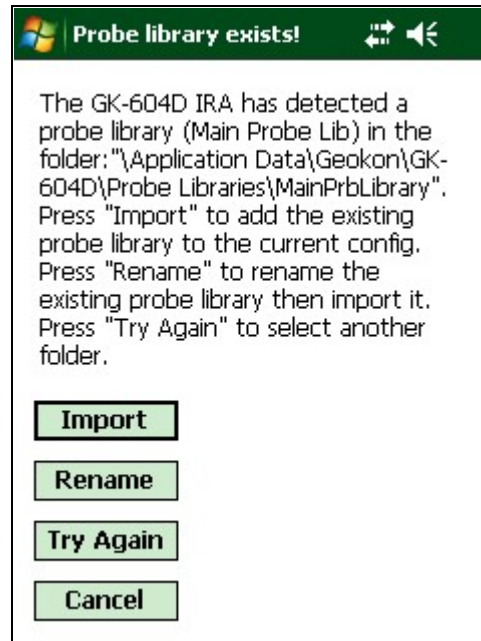


Figure 22 - Probe Library Exists

After the initial workspace and probe library are created the GK-604D IRA will attempt to connect to an inclinometer probe. If no probe has been previously connected then the error message seen in Figure 23 will be displayed. By default the GK-604 IRA looks for a probe connection on COM5 but will remember the COM number of the last successful connection. Please see section 2.2 for more information regarding establishing a connection with an inclinometer probe.

Regardless of the connection status, the newly created workspace and probe library will be opened by default and you will be able to create new project(s) and add new hole configurations to your workspace as well as adding new probes (settings) to the new probe library.

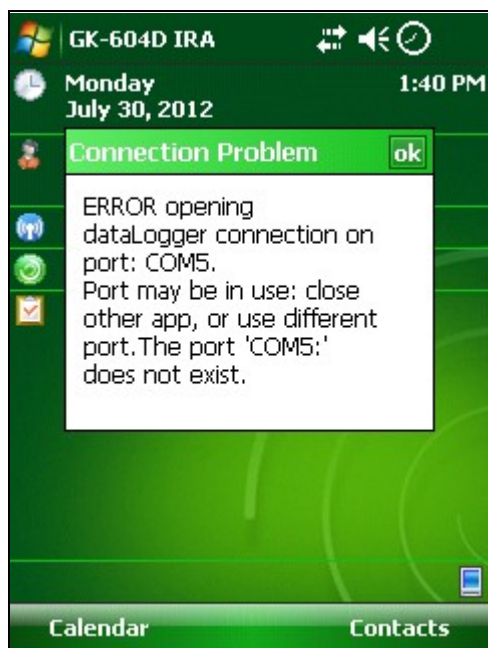


Figure 23 - Probe Connection Problem

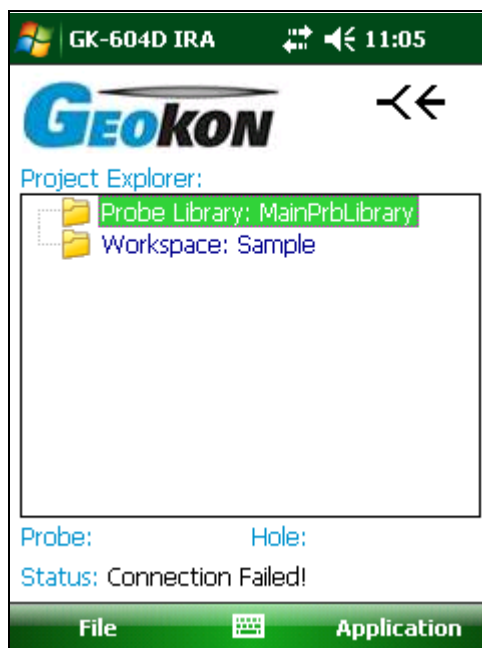


Figure 24 - Empty Workspace and Probe Library

 **Note:** With all subsequent attempts to connect to the Remote Module, please ensure that the “Power On” button on the Remote Module has been pressed (blue light will be blinking) before launching the GK-604D IRA.

3. User Interface

3.1 Overview

The GK-604D IRA user interface contains a number of navigation controls designed to make job of selecting application elements and functions easier. These navigation controls present an organizational view of the active workspace, inform the user about the state of the application, and provide the user with tools to configure and control Geokon devices.

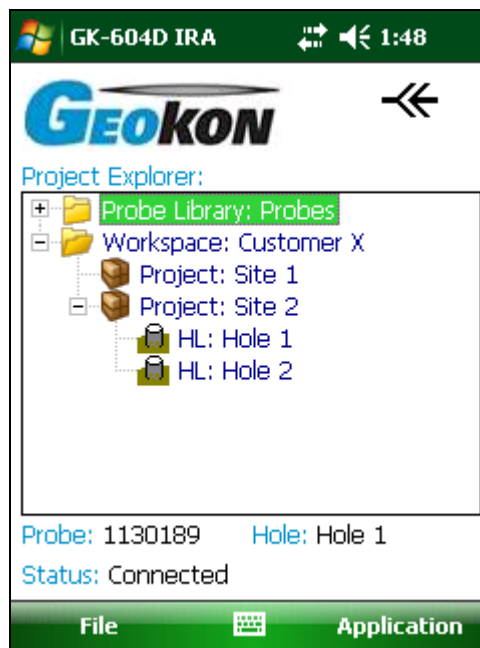


Figure 25 - User Interface

The GK-604D IRA User Interface is comprised of several core components:

Project Explorer	Element selection tool. Context (drop-down) menu.
Application Menu	Allows display changes, project, hole and probe configuration and connection to the remote module.
File Menu	File and project explorer element exporting, importing and restoration. Data view/reporting options.
Status Area	Displays the currently selected hole and probe and status of the application.

3.2 Project Explorer

The Project Explorer is the primary navigation mechanism for moving around the GK-604D IRA workspace and probe library. The Project Explorer presents a view of the workspace including projects and holes and a view of the probe library that includes available probes. These views reflect the hierarchical relationship between these elements.

The highest element in the workspace hierarchy tree is a project. Projects allow a GK-604D IRA user to group holes into organizational units based on the user's preference. A project can reflect a specific site where holes have been drilled such as a construction project. This organizational feature makes it easy to find hole configurations along with related data files. The list of holes defined under the project can be viewed by selecting a specific project and expanding its branch in the explorer view (click on + sign preceding project name) (see Figure 25).

In the hierarchy of the project explorer, holes are child elements of a project. Hole settings can be edited by selecting the desired hole in the explorer tree. Once selected, hole settings can be displayed using "Edit Settings" from the Application Menu (Figure 27) or by using the context menu (Figure 26).

Much as a project is a child element of a workspace, a probe is a child element of a probe library.

3.2.1 Context Menu

From the Project Explorer, new workspace elements can be added using the context menu. Access the drop-down menu by tapping and holding the explorer element that is to be operated on. The context menu is context sensitive in that, based on the current selection, the appropriate elements will be enabled and others will be disabled. Figure 26 below shows the drop-down menu with the menu item, “Add Hole”, enabled (not grayed out) since a “project” element is selected in the Project Explorer.

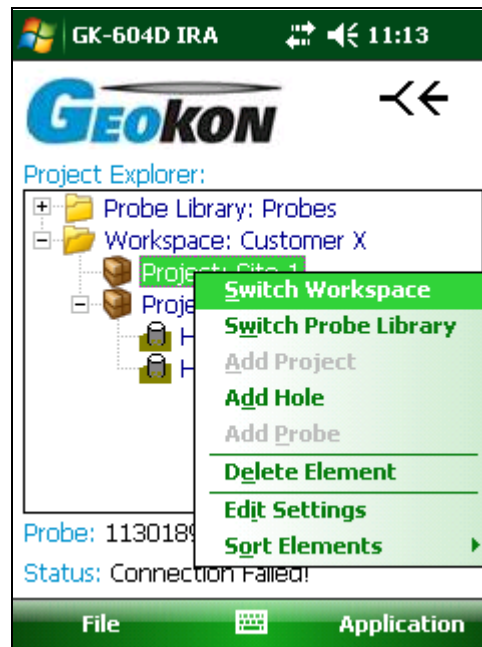


Figure 26 - Context Menu

As can be seen from Figure 26, the settings for a project explorer element can also be edited from the context menu.

Note that certain explorer elements can be sorted by newest or oldest first. The elements that can be sorted in a project explorer list are: Holes, Projects, and Probes.

3.3 Application Menu

The GK-604D IRA Application Menu provides access to the high level application functionality. It is located in the lower, right corner of the main window frame. Some items of this menu can also be accessed via the context menu. The Application Menu sub-items are further described below:

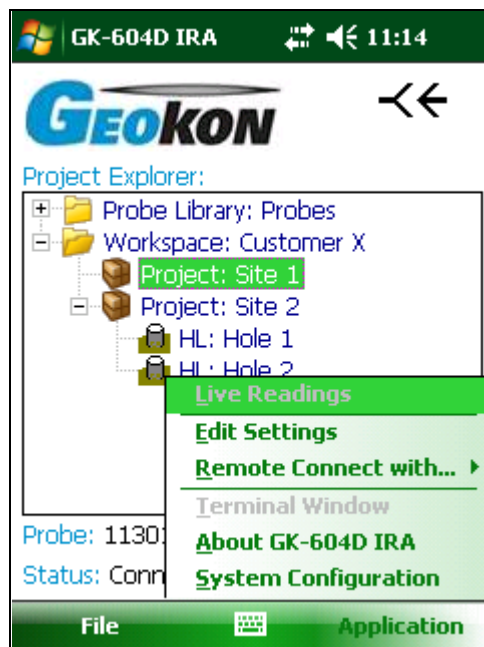


Figure 27 - Application Menu

3.3.1 Live Readings

This menu item will only be enabled if a successful connection has been established with a probe as indicated by the red ovals in Figure 28 below (see section 2.2 and 3.3.3 for information regarding connecting to probes).

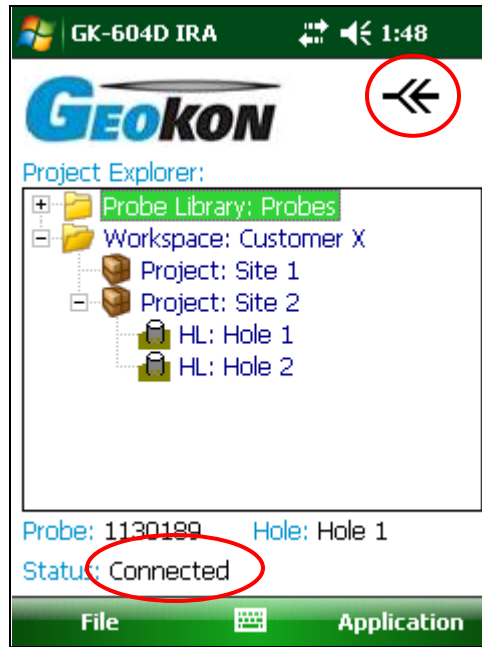


Figure 28 - Main Screen, probe connected

Tapping on the “Live Readings” menu item displays the screen shown in Figure 29).

- Readings are continuously updated from the remote. The data set always starts with ‘Dataset 1’ but can be switched at any time to ‘Dataset 2’ (usually after rotating the probe 180 degrees).
- At the start of a survey, the ‘Level’ is set to the “Starting Level” configured for a particular hole. Pressing either of the “Record Data” buttons (with a finger or tap of the stylus) records that set of A&B values and automatically changes the ‘Level’ (on screen) by the an amount based on the hole configuration (see section 4.1). The “Record Data” option can also be activated by pressing the “Enter” key on the right side of the keypad or the “Windows” key on the left side.

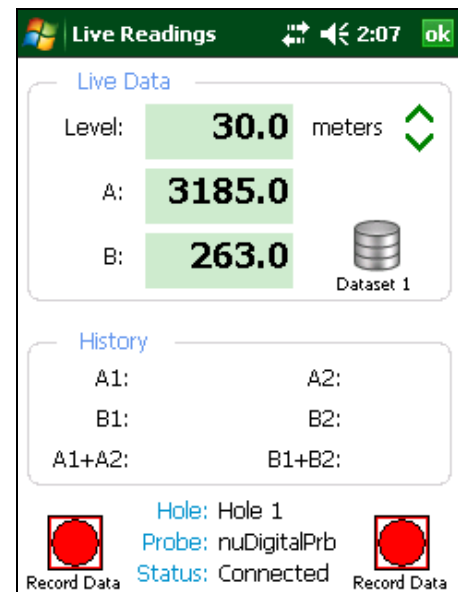


Figure 29 - Live Readings Screen

- A “beep” sound should be heard, confirming that the reading has been stored. If no beep is heard, tap the “volume” control at the top of the screen and adjust the volume.
- Be sure to move the probe to the new level and wait for the readings to stabilize before recording the next reading.

- At any point you can scroll the 'Level' using the green up and down arrow buttons on the screen and view data stored and checksums (lower half of the screen). When done taking readings, press "**ok**" (top-right corner of the screen). You will be given the option to save the readings to a file (see Figure 30).

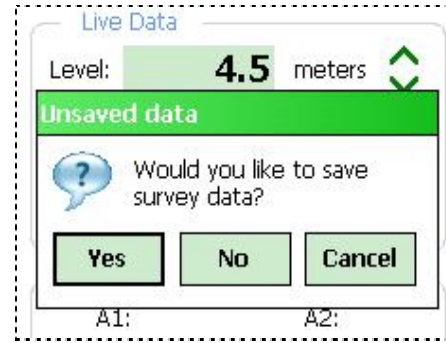


Figure 30 - Unsaved Data prompt

- Even if you select **No**, the readings will not be lost and can be restored later using the "File→Delete/Restore" menu option from the main screen.
- If **Yes** is selected, you then will be given the choice of saving with the auto-increment suffix on the standard filename (see Figure 31). Selecting Yes again causes the save operation to be carried out using a filename of the form: *[Hole_Name][3 digit AutoIncr_Suffix].GKN*
- If you select **No** (to the auto incrementing option) you will be shown the standard **File Save As** screen and you can modify the file name to anything you choose. Use the stylus to click on the keyboard icon (bottom) and make the changes you desire (see Figure 32).

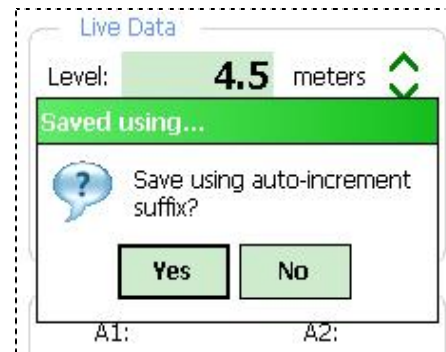


Figure 31 - Auto Increment Save



Figure 32 - Save File Screen

See section 3.3.6 (System Configuration) for more information about options that affect Live Readings and taking surveys.

3.3.2 Edit Settings

As with the Context Menu (see section 3.2.1), tapping the “Edit Settings” menu will invoke the Settings Editor for the currently selected Project Explorer element (See the section 4 for more information on settings).

3.3.3 Remote Connect with...

If at launch, the application displays the status, “Connection Failed” as shown in Figure 23 and Figure 24, the following options should be considered:

- Make sure the remote is turned on (blue light blinking).
- Select the “Application” menu option “Remote Connect with” (see Figure 27) and pick the COM port previously established in section 2.2 (see Figure 33).



Figure 33 - Remote Connect with...

A successful connection is reflected in the Main Screen status as in Figure 28.

3.3.4 Terminal Window

This feature requires an active connection to a probe. If enabled, tapping this menu option calls up the screen show in Figure 34. Using the “Terminal Window” requires the use of the on-screen keyboard to enter simple one or two character commands to the Remote Module. See Appendix D for more information regarding the Remote Module command structure.

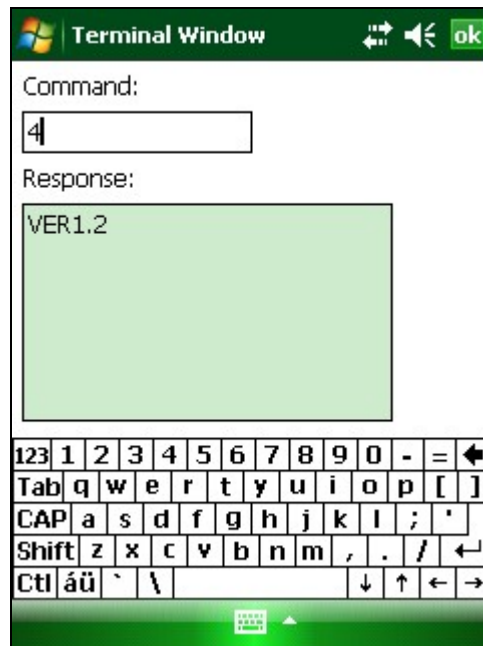


Figure 34 - Terminal Window

3.3.5 About GK-604D

This displays an information panel giving copyright information as well as the application version (see Figure 35). If a Remote Module is “connected” via Bluetooth then tapping on the “Remote Module Status” will display another screen giving status about the Remote Module (see Figure 36)



Figure 35 - About GK-604D

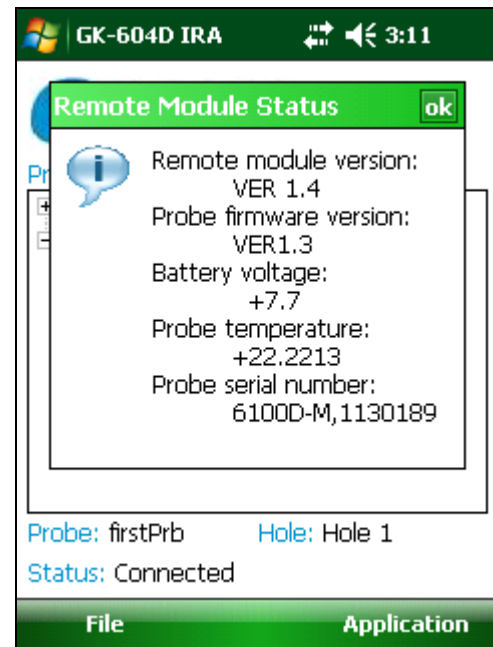


Figure 36 – Remote Module Status

Figure 36 depicts the status available for a digital Remote Module and probe. For analog systems, only the Remote Module version and battery voltage is listed.

3.3.6 System Configuration

This screen allows selecting options that affect how the system works and how a survey is taken (see Figure 37). The sub-sections that follow describe each parameter in detail.

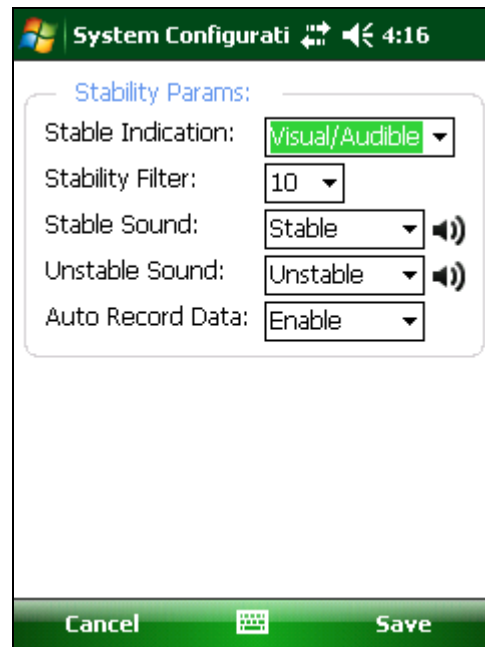


Figure 37 - System Configuration

3.3.6.1 Stable Indication

Valid choices for this selection include:

- | | |
|-------------------------|---|
| None | On the Live Readings Screen, the only indication of stability will be to monitor the A and B readings (see Figure 29). |
| Visual Only | When this stability indication is selected an icon is displayed on the Live Readings Screen, indicating whether the reading is stable or not (see Figures 38 and 39). |
| Visual / Audible | When this stability indication is selected, in addition to the icon described above, an audible indication is played indicating readings stability or instability (see Figures 40 and 41, as well as sections 3.3.6.3 and 3.3.6.4). |

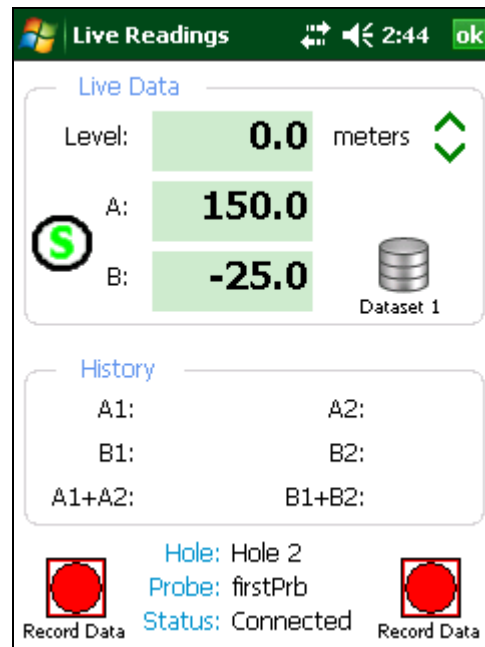


Figure 38 - Stable Indication

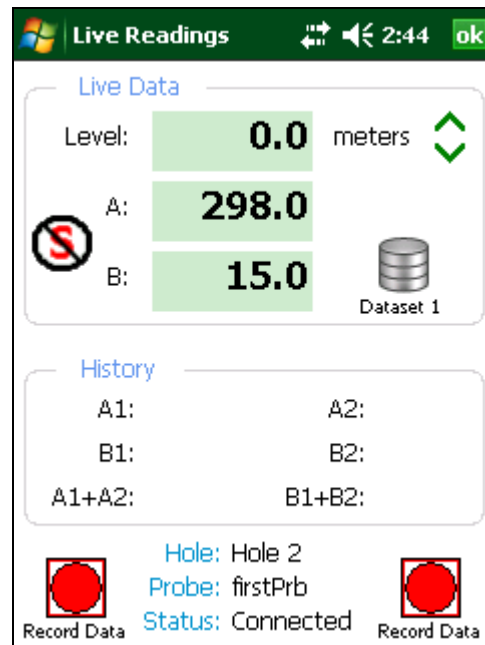


Figure 39 - Unstable Indication

3.3.6.2 Stability Filter

If the “Stable Indication” (see section 3.3.6.1) selection is set to something other than “None”, this parameter will be enabled and a drop-down list will facilitate the entry of a number that is used to determine readings stability (a value less than 10 is recommended).

When taking live readings, if the difference between two subsequent readings of the A **and** B channels are less than or equal to the “Stability Filter” then the reading will be deemed stable and, if enabled, the “Stability Indication” icon (see Figures 38 and 39) will be set accordingly.

3.3.6.3 Stable Sound

If the “Stable Indication” (see section 3.3.6.1) selection is set to “Visual/Audible”, this parameter will be enabled and a drop-down list will display the choices of “sounds” that the HHD can make when a stable reading is achieved in the “Live Readings” screen (see Figures 29 and 38).

Tapping on the icon to the right of the “Stable Sound” selection plays a preview of the actual sound heard.



3.3.6.4 Unstable Sound

If the “Stable Indication” (see section 3.3.6.1) selection is set to “Visual/Audible”, this parameter will be enabled and a drop-down list will display the choices of “sounds” that the HHD can make when the readings achieved in the “Live Readings” screen are determined to be unstable (see Figures 29 and 39).

Tapping on the icon to the right of the “Unstable Sound” selection plays a preview of the actual sound heard.



3.3.6.5 Auto Record Data

If this selection is set to “Enable”, upon entry into the “Live Readings” screen, the “Auto Record” feature will be enabled (see Figure 40).

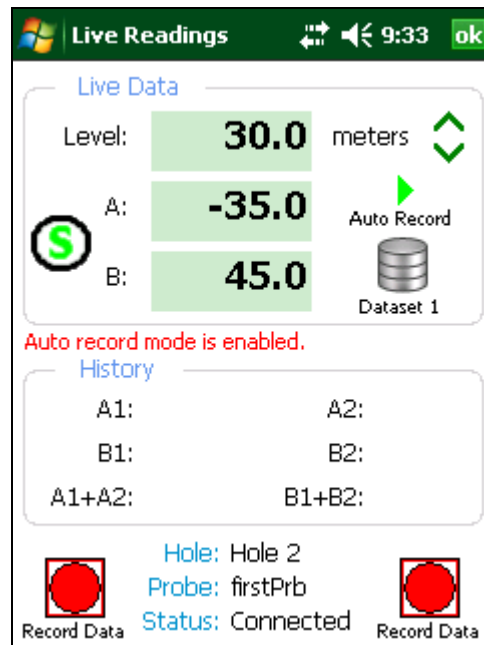


Figure 40 – Auto Record Enabled

To activate the “Auto Record” feature, tap on the “Play” icon to the right of the “A” reading text box. The “Play” icon will be replaced with the “Pause” icon, the red text status message will change to “Auto record mode is active” and, if the readings are stable, the first reading will automatically be recorded (see Figure 41).

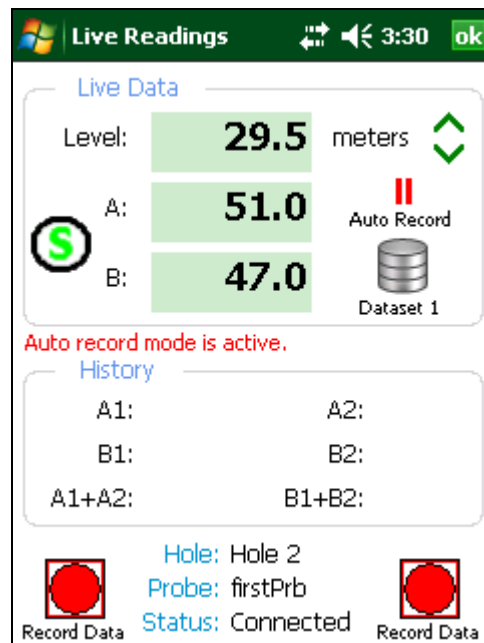


Figure 41 - Auto Record Active

The list of steps below illustrates the proper way to utilize the “Auto Record” feature. For the purpose of this example the following is assumed:

- the hand-held device is connected via Bluetooth to the Remote Module
- in System Configuration, the “Stable Indication” parameter is set to “Visual/Audible”
- the “Auto Record Data” parameter is set to “Enable” (see Figure 37).
at the start of an “Auto Record” sequence, the probe should be down the casing at the starting level, in the “A+” orientation.

1. Tapping on the “Live Readings” menu item displays the screen shown in Figure 40).
2. As in the normal operation, readings are continuously updated from the remote. The data set always starts with ‘Dataset 1’ (can be switched at any time to ‘Dataset 2’). At the start, the “Level” is set to the “Starting Level”, previously set in the Hole Settings screen (see section 4.1, Figure 67).
3. Tap on the “Play” icon to activate the “Auto Record” feature. The red status text message will change to “Auto record mode is active” and the green “Play” icon will change to the red “Pause” icon. If the readings are stable, the initial A & B readings will be taken and a “beep” sound should be heard, confirming that the readings have been stored. If no beep is heard, tap the “volume” control at the top of the screen and adjust the volume.
4. By pulling on the inclinometer cable, move the probe to the next level, ensuring that the cable marker/ferrule sits securely in the cable hold. Approximately 1 second after moving the probe, the system will determine that the readings are no longer stable. The stability icon will be set to its unstable state and the “Unstable” sound selected in the “System Configuration” screen (see Figure 37) will be played.

Approximately 2 seconds after the cable marker/ferrule is locked in the cable hold, the system will determine that the readings are again stable and respond by setting the stability icon to its stable state and playing the selected “Stable” sound (see Figure 41). Immediately following the stable sound, the current readings are stored, the record “beep” is heard and the level is decremented by the pre-selected interval.



5. Repeat step 4 until all the “A+” readings have been taken.

6. Tap the “Dataset 1” icon and observe that the red status text message will change to “Auto record mode is paused” and the “Pause” icon will change to the “Play” icon while “Dataset 1” becomes “Dataset 2” (see Figure 42).

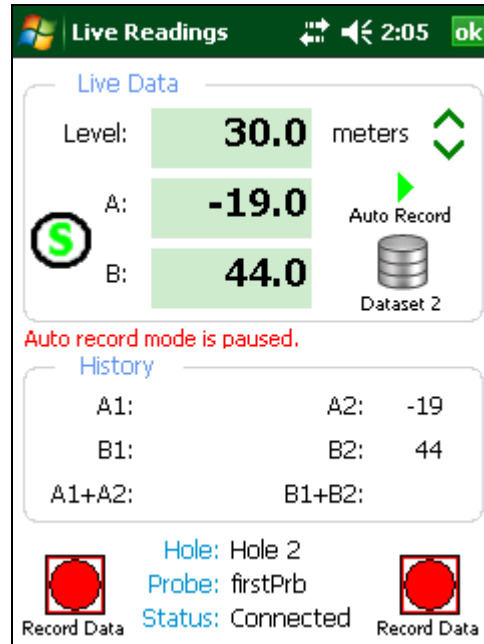


Figure 42 - Auto record paused, Dataset 2 selected

7. After rotating the probe 180 degrees, lower it back to the “Starting Level” appropriate for this hole. Repeat step 3.
8. Repeat step 4 until all the “A-” readings have been taken.
9. When done taking readings, press “ok” (top-right corner of the screen). You will be given the option to save the readings to a file (see Figure 30).
10. Even if “No” (see Figure 30) is selected, the readings will not be lost and can be restored later using the “File→Delete/Restore” menu option from the main screen.
11. If “Yes” (see Figure 30) is selected, then another dialog box will be displayed giving the choice of saving with the auto-increment suffix on the standard filename (see Figure 31). Selecting “Yes” again causes the save operation to be carried out using a filename of the form:
[Hole_Name][3 digit AutoIncr_Suffix].GKN
12. If “No” is selected (to the auto incrementing option) the standard **File Save As** screen will be shown giving the option of modifying the file name to another name of the user’s choosing. Use the stylus to click on the keyboard icon (bottom) and make the changes desired (see Figure 32).

NOTE: An “Auto Record” survey can be paused at any time and re-started as long as the probe is moved to the proper level reflected by the “Level:” display. When an Auto Record survey is paused, the data can still be recorded in the “normal” fashion by tapping on the “Record Data” buttons.

3.4 File Menu

The file menu is used to import and export Project Explorer element settings along with data export, viewing and report generation. It also is used to fully delete and/or restore previous deleted Project Explorer elements (see Figure 43).



Figure 43 - File Menu



Figure 44 - Export Menu

3.4.1 Export Menu

The Export menu is used to export hole data and Project Explorer element settings to a folder of the user's choosing (see Figure 44).

3.4.1.1 Export Data Menu

The Export Data menu allows exporting of data from the current hole - selected either via the Project Explorer or listed in the status area. Figure 45 shows the files available for hole, "Hole1". A file may be selected by tapping and holding on the file name. When a context menu is displayed, tap on "Select" to select the file for exporting. Multiple files may be selected. Once all the desired files are selected, tap "Export" to display the Save File window (Figure 46) where a new name and folder may be specified for each file.

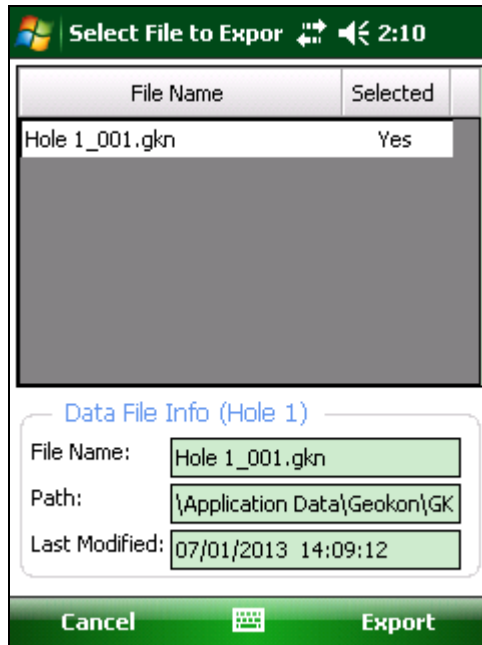


Figure 45- Export Data Window

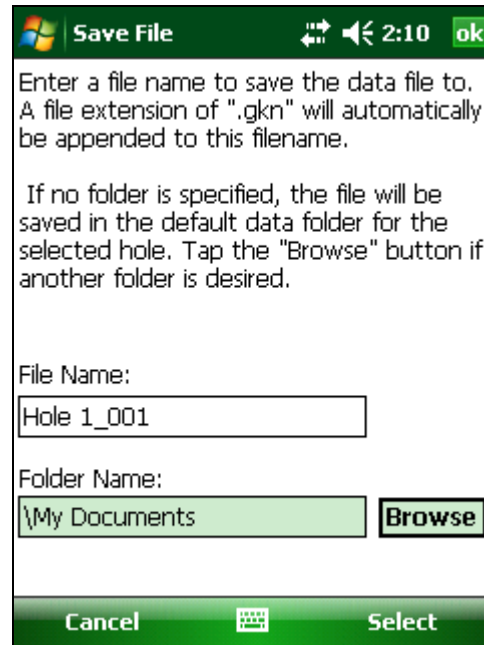


Figure 46 - Save Data File

3.4.1.2 Export Hole Settings

Clicking on this menu item displays the “Select Export Path” window (see Figure 47), from which a path to export the hole settings file can be selected. All files within the hole element folder are compressed into a single export file. The naming format for the hole export file is:

<Selected Path> + <Hole Name> + “.lvhe”

3.4.1.3 Export Project Settings

Clicking on this menu item displays the “Select Export Path” window (see Figure 47), from which a path to export the project settings file can be selected. All files within the project are compressed into a single export file. The naming format for the project export file is:

<Selected Path> + <Project Name> + “.lvpe”

3.4.1.4 Export Probe Settings

Clicking on this menu item displays the “Select... ..Probe” window (see Figure 48), from which a probe can be selected. After selecting a probe, the “Select Export Path” window (see Figure 47) is displayed, from which a path to export the probe settings file can be selected. The naming format for the probe export file is:

<Selected Path> + <Probe Name> + “.gkpe”

3.4.1.5 Export Probe Library

Clicking on this menu item displays the “Select Export Path” window (see Figure 47), from which a path to export the probe library files can be selected. All files and folders within the probe library are compressed into a single export file. The naming format for the probe library export file is:

<Selected Path> + <Probe Library Name> + “.gple”

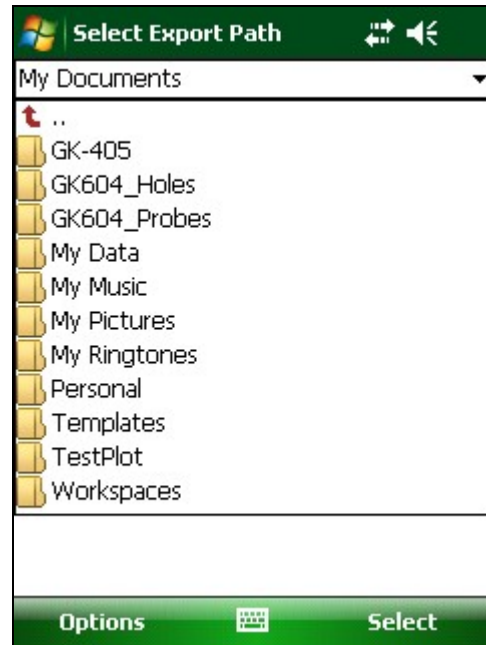


Figure 47 - Export Path Selection

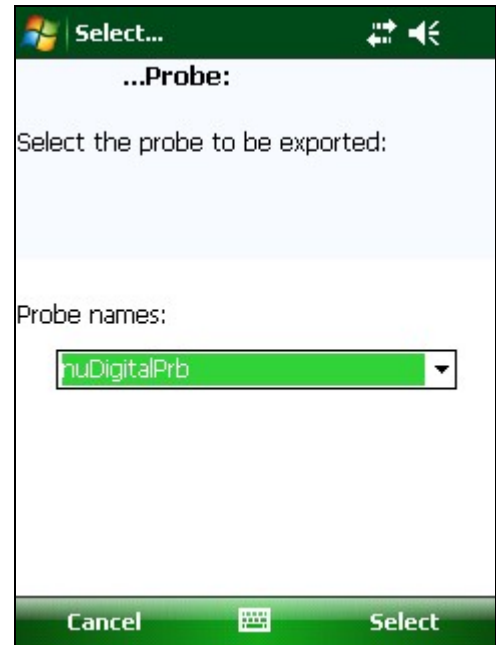


Figure 48 - Probe Selection Window

3.4.2 Import Menu

The Import Menu is used to import Project Explorer element settings (see Figure 49) that were previously exported using the Export Menu functions (see Figure 44).

3.4.2.1 Import Hole Settings

Clicking on this menu item displays the “Select .LVHE File” window (see Figure 50), from which a hole export file can be selected (see section 3.4.1.2). After selection, a new “Hole” will be created in the currently selected project. This new “Hole” will contain all the settings and any data files that were contained in the hole export file. If a hole with the same name already exists in the currently selected project a message will be displayed and the hole import will be cancelled.



Figure 49 - Import Menu

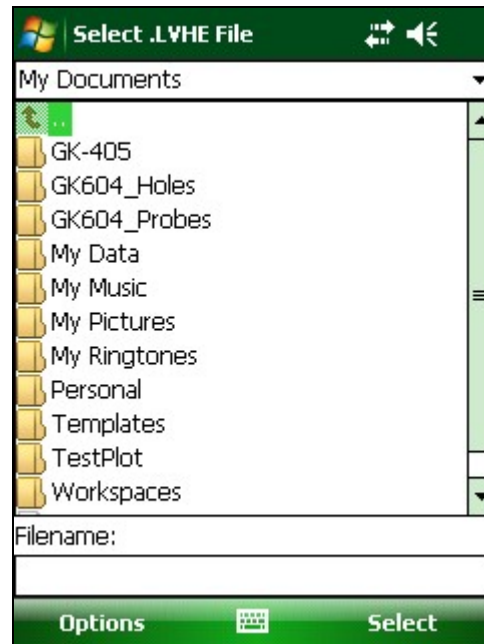


Figure 50 - Select Hole Export File

3.4.2.2 Import Project Settings

Clicking on this menu item displays the “Select .LVPE File” window (see Figure 51), from which a project export file can be selected (see section 3.4.1.3). After selection, a new “Project” will be created in the current workspace. This new project will contain all the settings and any “holes” that were contained in the project export file. If a project with the same name already exists in the current workspace a message will be displayed and the project import will be cancelled.

3.4.2.3 Import Probe Settings

Clicking on this menu item displays the “Select .GKPE File” window (see

Figure 52), from which a probe export file can be selected (see section 3.4.1.4). After selection, a new “Probe” will be created in the current probe library. This new probe will contain all the settings that were contained in the probe export file. If a probe with the same name already exists in the current probe library a message will be displayed and the probe import will be cancelled.

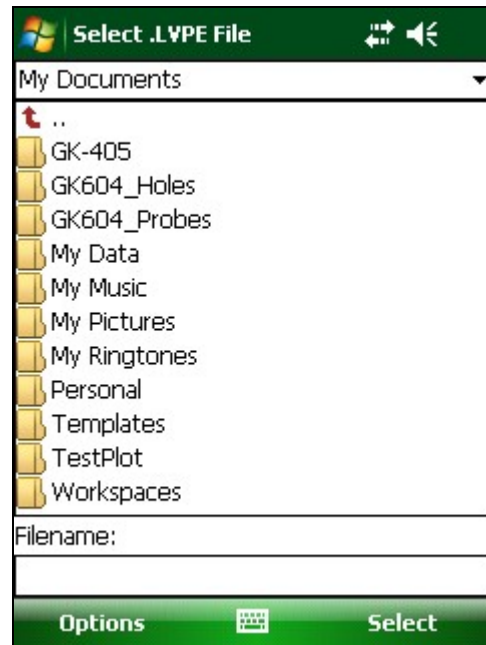


Figure 51 - Select Project Export File

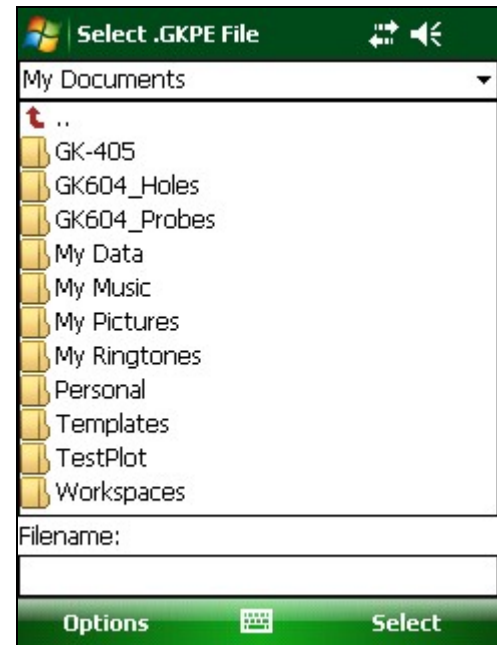


Figure 52 - Select Probe Export File

3.4.2.4 Import Probe Library

Clicking on this menu item displays the “Select .GPLE File” window (see Figure 53), from which a probe library export file can be selected (see section 3.4.1.5). After selection, a message query will be displayed (see Figure 54) asking the user if they would like to make the imported probe library the current one. Answering “Yes” to the query will replace the current probe library with the imported probe library. Answering “No” will simply add the new probe library to the list of probe libraries that the GK-604D IRA keeps track of. The new probe library can be “switched” to at a later date.

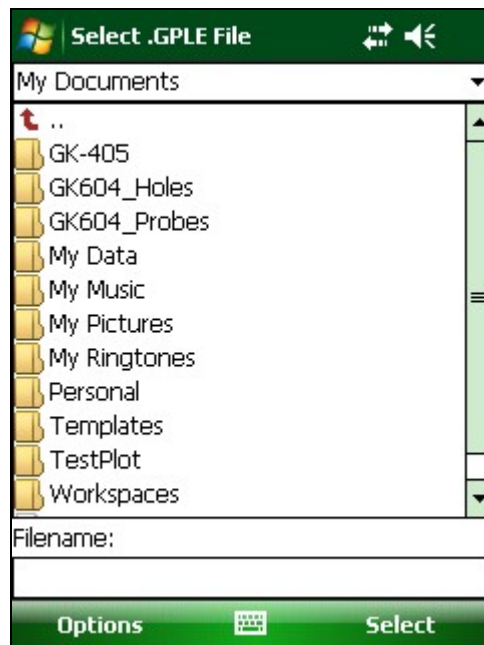


Figure 53 - Select Probe Library Export File



Figure 54 - Probe Library Switch after Import

3.4.3 View Data

When the View Data Menu is clicked the screen displayed in Figure 55 is shown. The Select View Options screen is used to select a view option (see Figure 56) and data files to view a graphical or tabular report.

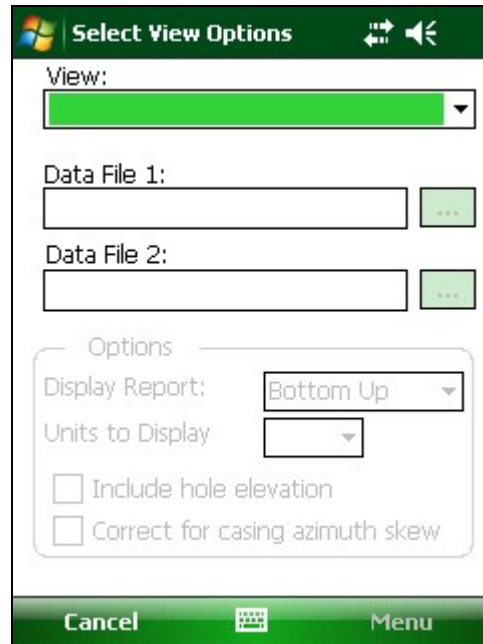


Figure 55 - Select View Options Window

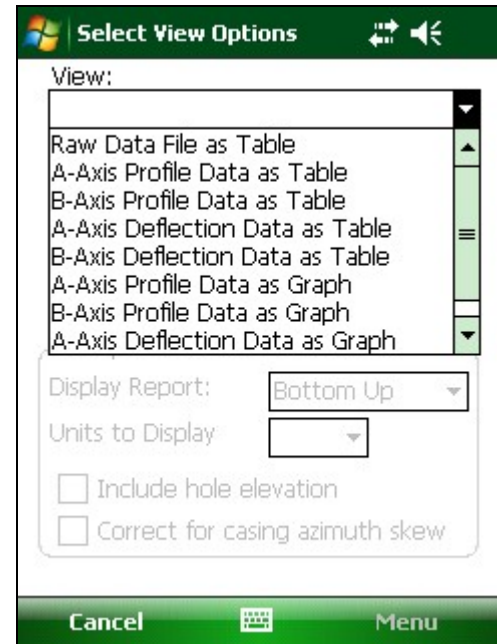


Figure 56 - View Option List

The available “View” options are:

3.4.3.1 Raw Data File as Table

This selection will cause the selected “hole” raw data to be displayed or saved in tabular form. Figure 57 shows the available options for any report. Figure 58 illustrates the report as viewed on the Archer unit. See Appendix C for examples of reports saved in text form. Tabular reports may also be saved in comma-separated value (.csv) or “Text” (.txt) format.

3.4.3.2 Axis Profile Data as Table

Selecting this option allows viewing or saving hole profile data for the A or B axis. The profile is calculated from the magnitude of the readings at each level (see Figure 59). This report lists the profile of the casing as calculated from the bottom of the casing upward or from the top down (see the Options pane in Figure 57). See Appendix C for an example of a profile report saved in text form. Tabular reports may also be saved in comma-separated value (.csv) or “Text” (.txt) format.

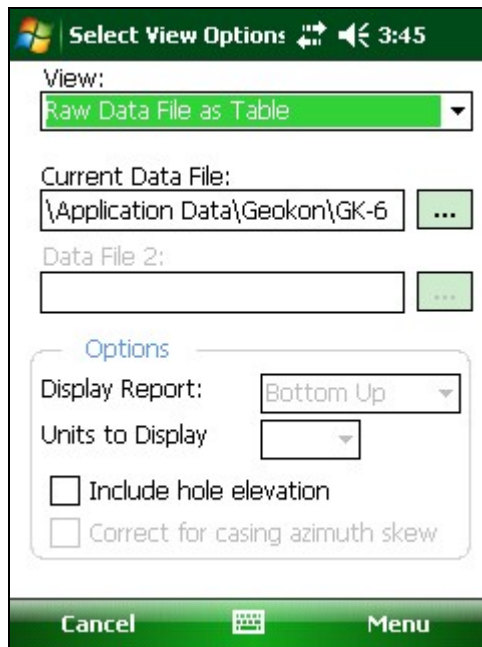


Figure 57 - Menu Options for Reports

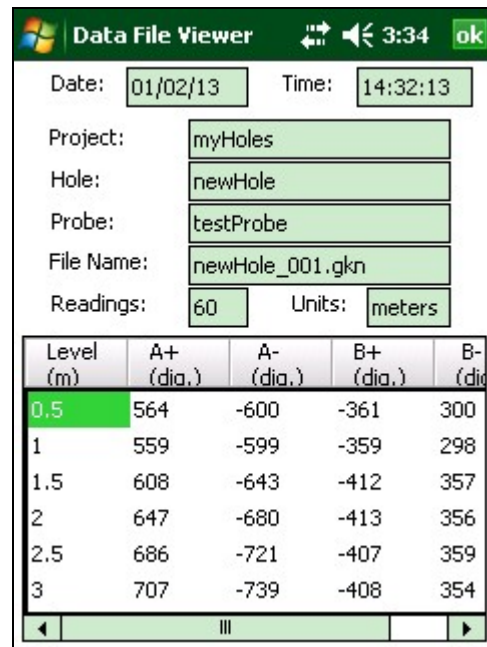


Figure 58 - Raw Data Report

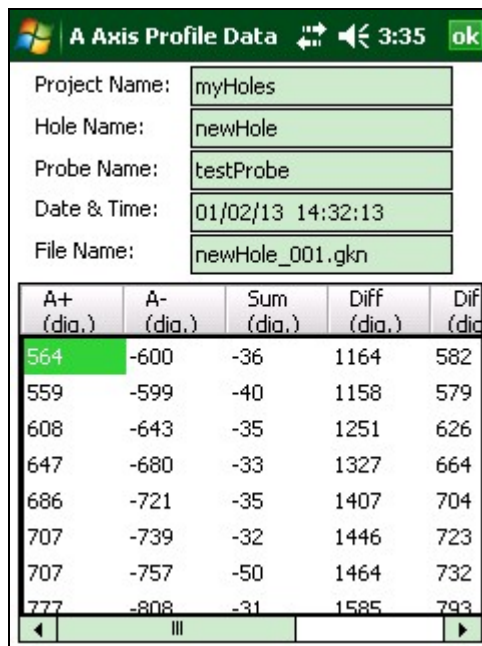


Figure 59 - Axis Profile Report

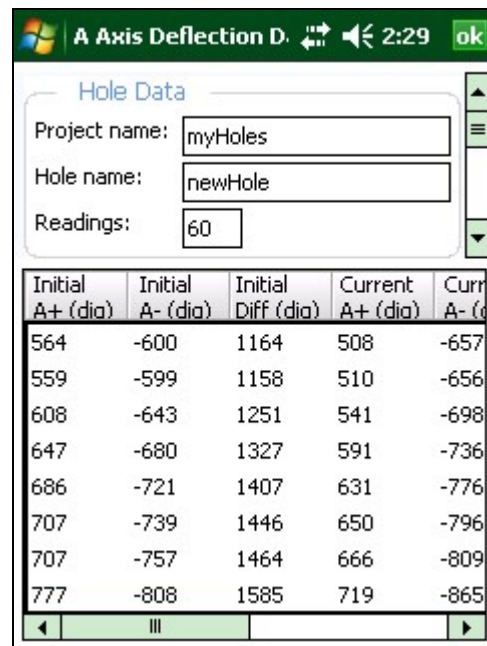


Figure 60 - Axis Deflection Report

3.4.3.3 Axis Deflection Data as Table

Selecting this option allows viewing or saving hole deflection data for the A or B axis. Deflection is determined from the accumulated change in

deflection between the two selected data files at each level. This report lists the deflection of the casing as accumulated from the bottom of the casing upward or from the top down (see Figure 60). See Appendix C for an example of a deflection report saved in text form. Tabular reports may be saved in comma-separated value (.csv) or "Text" (.txt) format.

3.4.3.4 Axis Profile Data as Graph

Selecting this option allows a graphical view of hole profile data and is useful for visualizing the actual installed characteristics (inclination, couplings, anomalies, etc.) of the casing. Figure 61 show a typical profile plot. Tapping on the icon in the upper-left corner of the plot (a circle with a vertical line) enables a "marker" line on the plot. Moving the marker line by tapping and dragging shows corresponding X and Y values below the plot (see Figure 62). "Screen-shots" of graphical reports may be saved in ".bmp" format".

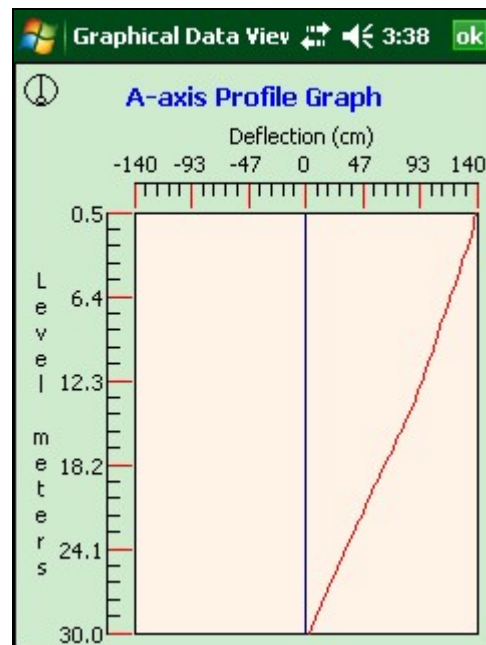


Figure 61 - Profile Plot

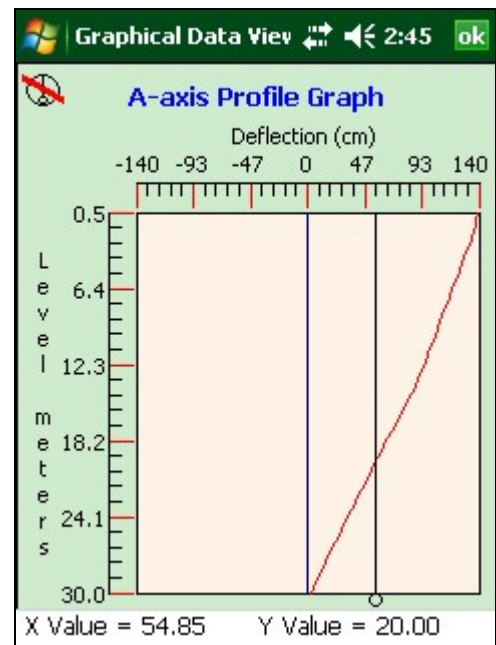


Figure 62 - Profile Plot - Marker On

3.4.3.5 Axis Deflection Data as Graph

Selecting this option allows a graphical view of hole deflection data for either axis and is useful for visualizing magnitude and direction of any movement of the borehole (see Figure 63). "Screen-shots" of graphical reports may be saved in ".bmp" format".

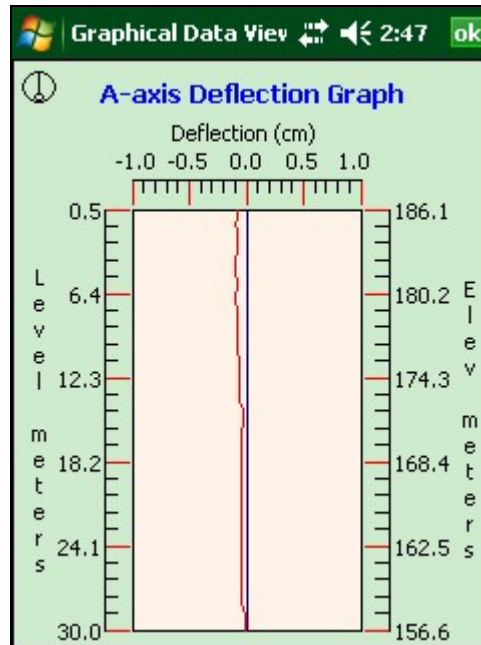


Figure 63 - Deflection Plot

3.3.4 Delete / Restore Menu

This menu allows data files and Project Explore elements to be permanently deleted or restored back to their original location. A special folder is reserved for storing project explorer elements that are deleted from a workspace. Tapping the Delete/Restore menu causes the GK-604D IRA to search this folder to see which elements are available for restoring or permanent deletion. As can be seen in Figure 64, in the example below there are holes, projects, probes and probe libraries that are stored in the special folder that can be either restored or permanently deleted. Figure 65 shows the window that is created when the "Holes" button is tapped in Figure 64.

In each element delete/restore window, an element may be selected by tapping and holding on the element name. When a context menu is displayed, tap on "Select" to select the file for deleting or restoring. Multiple files may be selected. Once all the desired files are selected, tap either "Delete" or "Restore" from the "Menu" options.

WARNING: Selecting "Delete" will permanently delete the selected element and later restoration will **NOT** be possible.

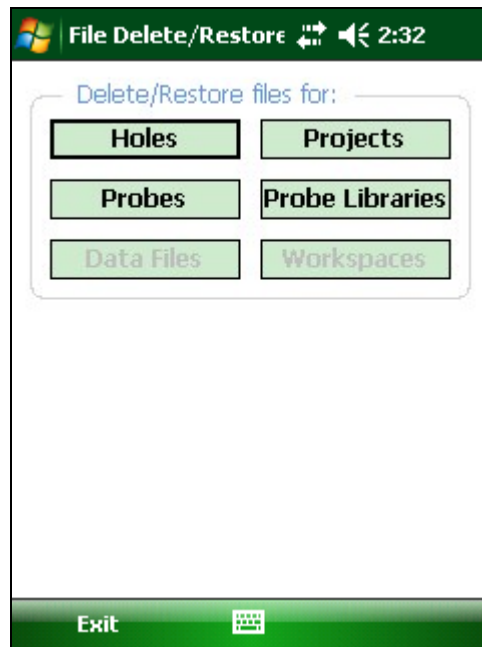


Figure 64 - Delete / Restore Window



Figure 65 - Hole Delete / Restore Window

3.3.5 Exit

Tapping on this menu item will cause the program to cease execution.

4. Configuring Project Explorer Elements

Each project explorer element has settings that can be configured. For some, like Workspace, Probe Library and Project the settings consist only of a name and description. Elements such as Holes and Probes require more configuration parameters such as English/metric units, initial level, and gage factors. These settings can be adjusted to meet the user's needs and the specifications of the probe. The software currently supports 3 different probe types and as many probe and hole configurations as the Field PC can store in memory. All these can be adjusted using the Edit Settings option from the Context or Application Menu.

4.1 Hole Configuration

Figure 66 depicts the Hole General Settings, the first screen of the Edit Hole Settings dialog:

- **Hole ID**
Read-only value, generated when the hole was created. Used internally by the GK-604D IRA.
- **Hole name**
Tap on the keyboard icon (bottom of the screen) to bring up the on-screen keyboard. Use it to enter a unique and descriptive hole name.
- **Description**
Using the on-screen keyboard, enter a brief description pertaining to the hole's location and purpose.
- **Probe Name**
Select the Probe Name from the drop down list. This associates a hole with a particular probe.

The screenshot shows the 'Edit Hole' dialog with the 'Hole General Settings' tab selected. The fields are as follows:

Hole ID:	HL0701143852
Hole name:	Hole1
Description:	First of several
Probe Name:	testPrb
Hole Units:	meters
Created On:	07/01/2013 14:42:12

At the bottom, there are navigation arrows (left and right) and a keyboard icon. The 'Cancel' and 'Menu' buttons are also visible.

Figure 66 - Hole General Settings

- **Hole Units**
The units that hole measurements will be taken in. Select either meters or feet from the drop-down list.
- **Created On**
Read-only date and time value, generated when the hole was created.
- **Starting Level**
Using the on-screen keyboard, enter a value for the initial level of the survey for this hole (see Figure 67).
- **Interval**
Enter an interval to be used for the survey. This value is dependent on Hole Units and is typically .5 meters or 2 feet.
- **Top Elevation**
This is an optional parameter and corresponds to the elevation at the top of the hole.
- **Azimuth Angle**
This is an optional parameter and allows correction of any casing deviation from the appropriate A+ direction.

The screenshot shows the 'Edit Hole' dialog with the 'Hole Parameters' tab selected. The fields are as follows:

Starting Level (meters):	30
Interval (meters):	0.5
Top Elevation (meters):	174
Azimuth Angle (degrees):	0

At the bottom, there are navigation arrows (left and right) and a keyboard icon. The 'Cancel' and 'Menu' buttons are also visible.

Figure 67 - Hole Parameters

When done editing, the settings can be saved via the “Menu->Save Settings” option.

4.2 Probe Configuration

Figure 68 depicts the General Probe Settings, the first screen of the Edit Probe Settings dialog:

- **Probe ID**
Read-only value, generated when the probe was created. Used internally by the GK-604D IRA.
- **Serial number**
Read-only parameter for digital inclinometer probes, read/write parameter for analog and compass probes.
- **Probe name**
Use the on-screen keyboard to enter a friendly name for the probe
- **Description**
Using the on-screen keyboard, enter a brief description pertaining to the probe
- **Probe type**
Select a probe type from drop-down list.
Choices are: Analog, Digital and Compass
 - Selecting **Compass** will rescale the software to properly display 0-360 degrees on the **Live Readings** screen.
 - In **Compass** mode, the GK-604D IRA can only read from the Geokon 6005-3 Spiral Indicator Probe which requires the GK-604-3 Analog Reel System or the GK-604-4 Interface Module.
 - In **Compass** mode, only one channel (A) is read and displayed on the **Live Readings** screen and only the A1 readings are stored in the data file.
- **Date created**
Read-only date and time value, generated when the probe was created.
- **Last edited**
Read-only data and time value, updated whenever the probe settings are modified.
- **A and B Channel Zero Shift**
To compensate for any offset at zero enter

The screenshot shows the 'Edit Probe' dialog with the 'General Probe Settings' tab selected. The fields are as follows:

Probe ID:	PRB0614152441
Serial number:	87641907
Probe name:	testPrb
Description:	
Probe type:	Analog
Date created:	06/14/2013 15:25:55
Last edited:	06/14/2013 15:25:55

At the bottom are 'Cancel' and 'Menu' buttons.

Figure 68 - Probe General Settings

The screenshot shows the 'Edit Probe' dialog with the 'Probe Coefficients (testPrb)' tab selected. The fields are as follows:

Zero Shift A:	0
Zero Shift B:	0
Gage Factor A:	1.0035
Gage Factor B:	1.0015
Gage Offset A:	0
Gage Offset B:	0

At the bottom are 'Cancel' and 'Menu' buttons.

Figure 69 - Probe Coefficients

appropriate values for the Zero Shift values (see the Inclinator Probe manual and Calibration sheet for more information). Digital probes may have these values programmed at the factory. When the probe type is set to Compass, the Zero Shift A value should be set to 200 (see Figure 69).

- **A and B Channel Gage Factors**

Using the on-screen keyboard, enter appropriate numbers for the 2 gage factors (see the Inclinator Probe manual and Calibration sheet for more information). Digital probes may have these values programmed at the factory. When the probe type is set to Compass, the Gage Factor A value should be set to 0.1 (see Figure 69).

- **A and B Channel Gage Offsets**

These values are typically "0" and are occasionally needed to remove an offset from a Compass probe. Offsets are entered in engineering units using the on-screen keyboard (see Figure 69). For a Compass probe there will be no "B" channel and the value for the B Channel should be left at "0". Digital probes may have these values programmed at the factory.

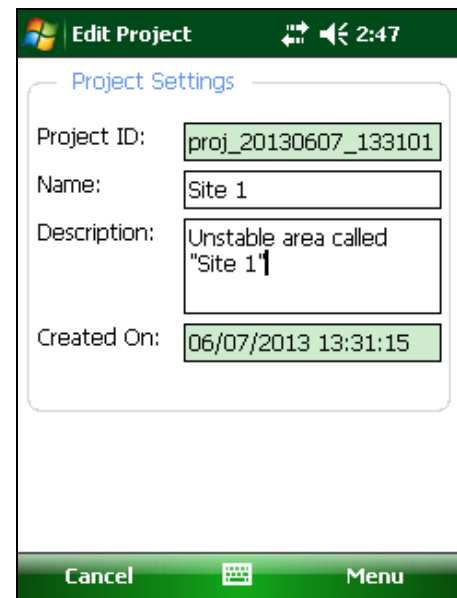
When the probe type is set to Compass, the offset can be determined by taking readings (using the Live Readings screen) and determining if the compass value is ever greater than 360. If so then the Gage Offset A value should be set to $360 - (\text{current reading} > 360)$. For example, if the current compass probe reading is 365 then the Gage Offset A value = $(360 - 365) = -5$.

When done editing, the settings can be saved via the "Menu->Save Settings" option. If connected to a digital probe, Zero Shift or Gage Factor changes can be uploaded to the probe via the "Menu->Save and Upload Settings" option.

4.3 Project Configuration

Figure 70 depicts the Projects Settings dialog:

- **Project ID**
Read-only value, generated upon project creation. Used internally by the GK-604D IRA.
- **Project Name**
Use the on-screen keyboard to enter a unique and descriptive project name.
- **Description**
Use the on-screen keyboard to enter a brief description pertaining to the project.
- **Created On**
Read-only date and time value, generated when the project was created.



The screenshot shows a mobile application interface titled "Edit Project" with a status bar at the top showing a signal strength icon, a battery icon, and the time 2:47. Below the title bar is a section titled "Project Settings" containing four fields: "Project ID" with the value "proj_20130607_133101", "Name" with the value "Site 1", "Description" with the value "Unstable area called 'Site 1'", and "Created On" with the value "06/07/2013 13:31:15". At the bottom of the dialog are two buttons: "Cancel" and "Menu".

Figure 70 - Project Settings

When done editing, project settings are saved via "Menu->Save Settings" options.

5. Files, Folders and Transferring Data

The GK-604D IRA uses several types of files and dedicated folder locations to keep track of Workspaces and Project Explorer element configuration files, such as hole and probe configuration files and data files. The default locations and names for most of these appear in Table 1:

Purpose	Default Folder	Filename
GK-604D IRA preferences and configuration	\\Application Data\\Geokon\\GK-604D\\	Config.xml
Workspace repository	\\Application Data\\Geokon\\GK-604D\\Workspaces\\	N/A
Probe Library repository	\\Application Data\\Geokon\\GK-604D\\Probe Libraries\\	N/A
Project repository (Workspace)	\\Application Data\\Geokon\\GK-604D\\Workspaces\\<WRK_SPC_FLDR>\\ ¹	.wkspc
Hole repository (Project)	\\Application Data\\Geokon\\GK-604D\\Workspaces\\<WRK_SPC_FLDR>\\<PROJECT ID>\\	.proj
Hole configuration	\\Application Data\\Geokon\\GK-604D\\Workspaces\\<WRK_SPC_FLDR>\\<PROJECT ID>\\<Hole ID>\\	.hole
Data Files (per Hole)	\\Application Data\\Geokon\\GK-604D\\Workspaces\\<WRK_SPC_FLDR>\\<PROJECT ID>\\<Hole ID>\\data\\	*.gkn
Probe repository (Probe Library)	\\Application Data\\Geokon\\GK-604D\\Probe Libraries\\<PRB_LIB_FLDR>\\ ²	.prblib
Probe configuration	\\Application Data\\Geokon\\GK-604D\\Probe Libraries\\<PRB_LIB_FLDR>\\<Probe ID>\\	.probe

Table 1 – Folder paths and File Names

1. <WRK_SPC_FLDR> is usually the same as the workspace name but is not required to be.
2. <PRB_LIB_FLDR> is usually the same as the probe library name but is not required to be.

NOTE: Manual editing any of the configuration files or renaming folders above may result in data loss and is strongly discouraged!

5.1 File Transfer

In general, the only files generated by the GK-604D IRA that will have to be transferred are the “hole” data files, although periodically archiving others on a “master” PC is recommended. Connecting the Field PC to a desktop or laptop PC using the supplied USB cable (Type A to mini B) is straight forward and allows the user to view the Field PC’s storage as a flash drive on the desktop/laptop; you can then simply drag the files around to any folder on the desktop/laptop.

- If you are using Windows XP you will need to download and install the program, “ActiveSync”. This application is available for free from the Microsoft site (www.microsoft.com and search for “Active Sync download”). Once installed (generally requires a reboot), simply connect the USB cable from the Field PC and then open “My Computer” on the XP machine and see a “PDA” entry under drives. Just double click on it to see the folders in the Field PC.
- If you are using Windows Vista or Windows 7, Microsoft includes software called Windows Mobile Device Center and you should be able to immediately connect the Field PC and see it in the “Computer” window.

It is not necessary to set up any ‘syncing’ options although it can easily be accomplished. Another Bluetooth partnership can also be set up from your desktop/laptop (assuming they have Bluetooth modules) to the Field PC and transfer files that way.

All of these options (and more) are described in the Field PC’s Reference Guide.

5.2 Backing up configurations

To guard against accidental data loss and as a matter of good computer technique, critical data and configuration files should be periodically backed up.

- Entire projects can be backed up using the Project Export function from the File menu. After exporting, the resulting “.lvpe” file should be transferred to a desktop PC using the techniques described in section 5.1
- Probe Libraries can be backed up using the Probe Library Export function from the File menu. After exporting, the resulting “.gple” file should be transferred to a desktop PC using the techniques described in section 5.1
- Although backing up a project automatically includes any data files stored as part of the project element “hole” structure, data files can be individually backed up per hole using the Data Export function from the File menu. After exporting, the resulting “.gkn” file should be transferred to a desktop PC using the techniques described in section 5.1

APPENDIX A. Inclinometer Theory

A.1. Inclinometer Theory

In the geotechnical field inclinometers are used primarily to measure ground movements such as might occur in unstable slopes (landslides) or in the lateral movement of ground around on-going excavations. They are also used to monitor the stability of embankments, slurry walls, the disposition and deviation of driven piles or drilled boreholes and the settlement of ground in fills, embankments, and beneath storage tanks.

In all these situations it is normal to either install a casing in a borehole drilled in the ground, to cast it inside a concrete structure, to bury it beneath an embankment, or the like. The inclinometer casing has four orthogonal grooves (Figure 71) designed to fit the wheels of a portable inclinometer probe (Figure 72). This probe, suspended on the end of a cable connected to a readout device, is used to survey the inclination of the casing with respect to vertical (or horizontal) and in this way to detect any changes in inclination caused by ground movements.

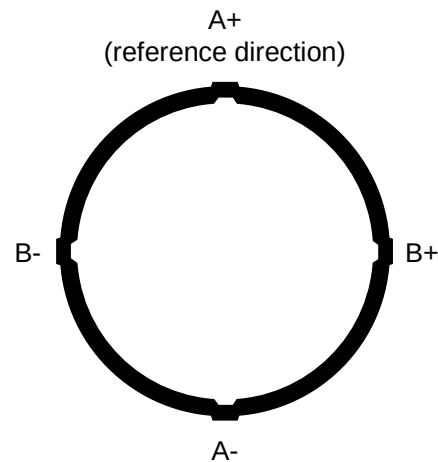


Figure 71 - Inclinometer Casing (end view)

The probe itself contains two MEMS, (Micro Electro-Mechanical Sensor), accelerometers, which flex when acted on by the force of gravity. Since the output voltage is proportional to the sine of the angle of inclination, the output is also proportional to horizontal deviation of the borehole (or the vertical deviation of a horizontal borehole).

In order to obtain a complete survey of the ground around the installed inclinometer casing it is necessary to take a series of tilt measurements along the casing. Typically an inclinometer probe has 2 sets of wheels separated by a distance of 2 feet (English system) or .5 meter (Metric system). A casing survey would begin by lowering the probe to the bottom of the casing and taking a reading. The probe would then be raised at 2 foot (English system) or .5 meter (Metric system) intervals and a reading taken at each interval until the top of the casing is reached. The set of readings thus generated is called the A+ readings. Marks on the cable at 2 foot (English) or .5 meter (Metric) spacing facilitate the process. The probe is then removed from the casing, rotated through 180°, replaced in the casing, lowered to the bottom of the borehole and a second set of readings (the A- set) obtained as the probe is raised at the reading interval.

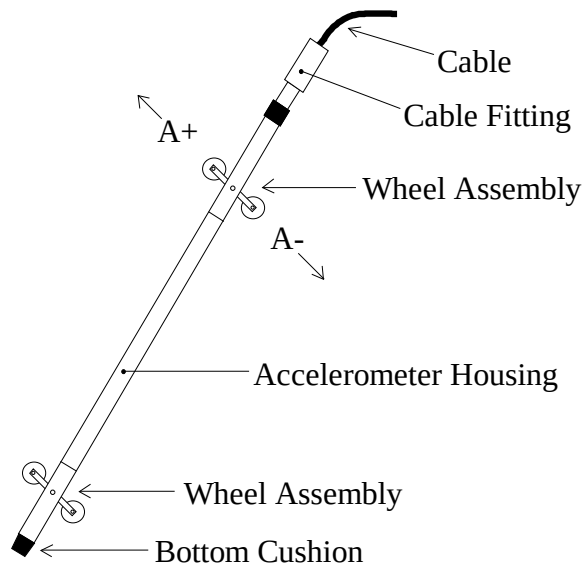


Figure 72 - Inclinator Probe

Inclinometer probes usually contain two accelerometers with their axes oriented at 90° to each other. The A axis is in line with the wheels (Figure 72 illustrates) with the B axis orthogonal to it. Thus, during the survey, as the A+, A- readings are obtained, the B+, B- readings are also recorded.

During the data reduction these two sets of readings (A+, A- and B+, B-) are combined (by subtracting one set of readings from the other) in such a way that the effect of any zero offset of the force balance accelerometer is eliminated. [This zero offset is the reading obtained from the inclinometer probe when it hangs vertical. Ideally the offset (or bias) would be zero, but usually there is a zero offset which can change during the life of the probe due to drift of the transducer, wear and damage of the wheels or most likely due to a sudden shock to the transducer caused by dropping or allowing it to hit too hard against the bottom of an installed inclinometer casing.]

Subsequent surveys of the inclinometer casing, when compared with the original survey, will reveal any changes of inclination of the casing and locations at which these changes are taking place. Analysis of the change of inclination is best performed by computing the horizontal offset of the upper wheels relative to the lower wheels which has produced the tilting (θ) over the reading interval (L) of the survey (usually the wheel base of the probe, 2 feet for English systems, .5 meter for Metric). At each position of the inclinometer the two readings taken on each axis (A+, A- and B+, B-) are subtracted from each other leaving a measure of $\sin\theta$. This value is then multiplied by the reading interval (L) and the appropriate factor to output horizontal deflection in engineering units (inches for English, centimeters or millimeters for Metric) (see Figure 73).

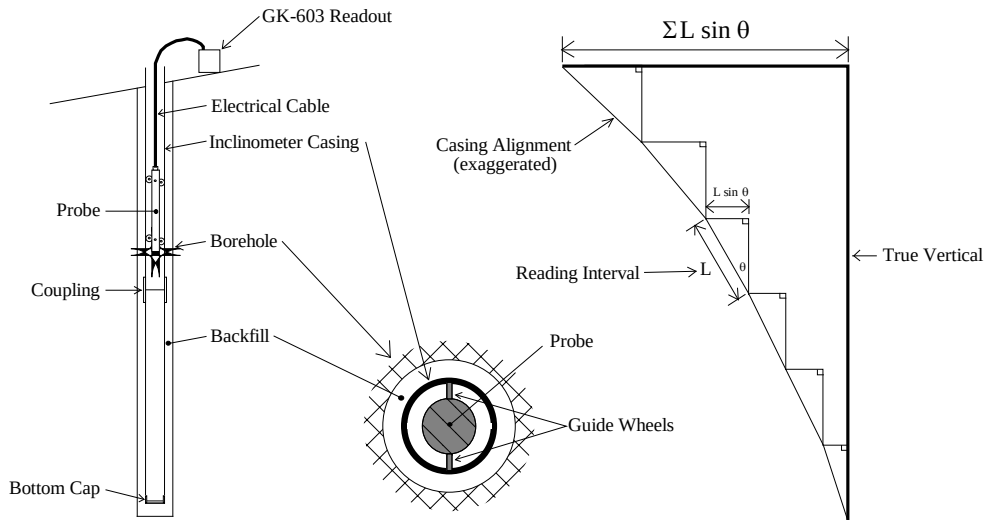


Figure 73 - Inclinator Survey Description

When all these incremental horizontal deflections are accumulated and plotted beginning at the bottom of the borehole the net result is to produce a plot of the change in horizontal deflection between the time of the initial survey and the time of any subsequent survey (see Figure 74). From such a deflection plot it is easy to see at which depth the movement is occurring and its magnitude.

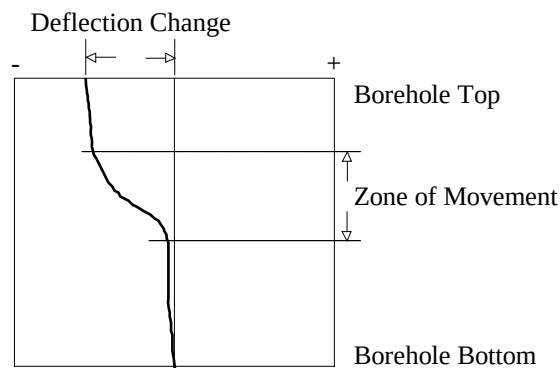


Figure 74 - Plot of Borehole Deflection

Other methods of analysis can be used but generally add little to the overall understanding of the situation. For example, using a single set of data, a profile of the borehole can be created. Also, a plot can be made of the actual change in reading (inclination) at each measurement depth increment. A plot of this nature reveals the depths at which movement is occurring. But this information can be obtained from the change in deflection curve with little difficulty.

One other analysis is the Check Sum (or Instrument Check) which can be used to measure the quality of the survey data. The quality of the data can be impaired by any or all of the following;

- ◆ Skipping over or duplicating a reading.
- ◆ Not allowing the inclinometer sufficient time to come to rest before taking a reading.
- ◆ Not allowing sufficient time to allow the probe to reach temperature equilibrium before commencing the survey.
- ◆ Malfunction of the probe, cable or readout device. This may be the result of shock, moisture, low battery conditions, opens or shorts in the cable or probe, etc.
- ◆ Carelessness in positioning the wheels so that the probe wheels do not rest on the same part of the casing from one survey to the next.
- ◆ Positioning the wheels so that they fall right on top of a casing joint so that the reading is unstable or simply erroneous.

The Check Sum analysis is performed by adding the A+, A- readings and the B+, B- readings. When this is done the part of the reading due to the tilt is eliminated leaving only a value which is equivalent to twice the zero offset of the inclinometer transducer.

A.2 Conducting the survey

The following is a synopsis of the steps involved in taking a survey (see section 3.3.1 for more details):

- 1) Attach the cable to the probe making sure that the connector is clean and the O-ring undamaged. Tighten the connector to ensure that the O-ring is compressed and watertight.
- 2) Twist the probe so that the uppermost wheel fits into the casing groove that faces the direction of the anticipated movement, (In the case of a slope this would be downhill, or, in the case of a foundation wall in the direction of the opening. This guarantees that the measured deflections will be positive. Lower the inclinometer probe to the bottom of the casing, To avoid damage to the probe be careful not to let the probe strike hard against the bottom of the hole.
- 3) Select the size of cable hold that matches the inclinometer casing and place it inside the top of the casing. Lift the inclinometer until the first cable marker sits in the cable hold.
- 4) Switch on the Archer, turn on the Remote Module (blue light blinking) then launch the GK-604D IRA. After verifying that the hand-held unit has connected to the probe, click on the "Live Readings" menu and observe the inclinometer reading. Wait until the probe temperature has stabilized and the reading doesn't change.

- 5) Make sure that the GK-604D IRA is set to Data Set 1. Take the first reading, pull up on the cable until the next cable marker sits in the cable hold and, after a short pause, take another reading.
- 6) Continue in this way until the top marker is reached, remove the cable hold, pull the inclinometer out of the hole.
- 7) Twist the probe through 180 degrees then lower it to the bottom of the hole. Tap the "Dataset 1" button to select data set 2.
- 8) Repeat steps 3 to 6.
- 9) Press the "ok" to save the data.

A.3 Checksums and "Face Errors" on Inclinometer Probes

Many users have expressed concern about **checksums or "face errors"** on inclinometer probes. They are concerned with the affect of the "face error" on the accuracy of the readings. The purpose of this section is to show that under normal circumstances the affect of the "face error" or checksum is negligible even with checksums as large as 2000. **The only time a problem would arise is if the face error or checksum was to change between the two halves of a survey. This is why it is extremely important to not bang the probe on the bottom of the borehole between survey halves, and to not handle the probe roughly while out of the hole.**

The term "face error" comes from surveying terminology. It is normal for all theodolites to have a "face error" which is caused by imperfections of alignment of the collimation axis and other misalignments. These "face errors" are removed routinely by taking two readings of the theodolite: one angle is measured with the face of the vertical scale on the left of the theodolite and another with the face of the vertical scale on the right of the theodolite. The average of the two readings "face right" and "face left" gives the **true angle since the "face error" cancels out.**

Similarly with the inclinometer probe: the "face error" arises from the fact that the axis of the inclinometer probe is not parallel with the electrical axis of the internal, force-balance, servo- accelerometer transducer. Once again the "face error" is eliminated by taking two surveys of inclinometer readings one with the wheels of the inclinometer probe pointing in one direction and another with the wheels of the probe at 180° to the first direction. If the first set of readings are all too large by the amount of the "face error" then the second set of readings will be too small by the amount of the "face error" and the average or sum of the two readings will be a measure of the true inclination since the affect of the face error will be totally eliminated.

A.3.1 Effect of “Face Error” on reading accuracy

The “face error” or check-sum can only affect the accuracy of the readings if it affects the calibration of the probe. This is possible because the output of the probe transducer is proportional to the sine of the inclination from the vertical and the sine function is non-linear.

Imagine, for a moment, that the electrical axis of the transducer is five degrees away from being parallel with the axis of the inclinometer. This would give rise to a “face error” of 0.1743. (The inclinometer reader displays $20,000 \sin \theta$). So, one set of readings would be all too large by this amount and the other set of readings from a normal inclinometer survey would be too small by this amount, but the sum of the two readings would be accurate. The “face errors” having canceled out. However, if we assume that the hole is almost vertical then the transducer will be tilted at an angle of 5° . The difference in the slope of the sine function at any point is equal to the cosine of the angle at that point. The cosine of 0° is 1.0000 the cosine of 5° is 0.996 so that the effect of this “face error” on the calibration of the probe is to increase it by a factor of $1/0.996 = 1.004$.

The practical implication of this would mean that if the apparent deflection of a borehole was 100 mm, the true deflection would be 100.4 mm. For practically all applications, in the real world, the difference is insignificant and is a lot less than the differences which normally occur from survey to survey i.e. a lot less than the precision of the inclinometer probe survey. (Lack of precision is caused by a failure to position the wheels of the probe in exactly the same place from survey to survey; failure to wait sufficiently long to allow the probe transducer to come to rest before reading; and random dirt in the inclinometer casing).

Note that the normal system accuracy of an inclinometer probe is ± 7 mm in 30 meters. By comparison it can be seen that the normal system accuracy or precision is very much larger than the calibration error caused by the “face error” and that for all practical purposes the “face error” is of no consequence and can be completely discounted if it is less than 2000 digits.

(As another example, supposing the check-sum was as large as 5000 digits. This is equivalent to a gross angular error of misalignment of almost 15 degrees. The effect on the calibration would be a little over 3 % so that the apparent deflection of 100 mm would be out by 3 mm which again is smaller than the normal data spread due to imprecision).

A.3.2 Measurement of “Face Error”

The “face error” is the reading shown by the inclinometer probe when it is perfectly vertical. In practice, the easiest way to obtain the “face error” is to run a normal inclinometer survey, with the two sets of readings at 180 °, and then to run a profile or deflection report. (see section C.2 and C.3, the column labeled “Diff”) Examination of the data will reveal **the average checksum which is equal to twice the “face error.”**

A.3.3 Setting of the “Face Error” to zero

There are three ways of setting the “face error” to zero. None of them are necessary from the point of view of improving accuracy.

A.3.3.1 Mechanically

At the time of manufacture the electrical axis of the transducer is adjusted by means of shims etc., until it points parallel to the axis of the inclinometer probe. This method suffers from the disadvantage that if the “face error” changes due to wear and tear on the probe and rough handling, or shock loading of the transducer then the probe needs to be returned to the factory for dismantling and re-adjustment.

A.3.3.2 Electrically

Electronic circuitry can be included in the probe so that the output of the transducer can be adjusted to zero when the probe is vertical. The disadvantage of this method is that it introduces electronic components into the inside of the probe which may alter with time, temperature and humidity and which, if the “face error” changes due to wear and tear or rough handling, will require the probe to be dismantled and the electronic circuitry readjusted. Also, this form of correction only masks the “face error”. It does not really remove it and if the “face error” is very large the calibration will be affected.

A.3.3.3 By software

The best way for setting the “face error” to zero is by applying an automatic correction to the measured readings using the software capabilities of the inclinometer readout box.

The procedure for setting the face error to zero is described in section 4.2 which covers the subject of “Zero shifts” which are the same as “face errors”. The advantage of this method lies in it’s simplicity and the ability to set the “face error” to zero at any time without dismantling the probe. This is the method chosen by Geokon.

Another advantage of this method is that it is possible by judicious choice of the “face error” entered into the software program to make one probe give exactly the same digits output as another probe. This is sometimes thought to be desirable where probes are switched and unbroken continuity of the raw data is desired. It is not necessary for reason of accuracy as has already been explained.

The disadvantage of this method is that, if the probe is changed, the operator must remember to change the zero shift offset in the program to accommodate the “face error” of the new probe.

A.3.4 Conclusion

It has been shown that for most practical purposes check-sums of less than 2000 digits are of no consequence and can be completely ignored providing the inclinometer survey is conducted in the normal way. (i.e.2 sets of readings at 180°) It has further been shown that the best method by far, for setting the “face error” to zero, is by means of the software capabilities in the inclinometer reader. This is the method chosen by Geokon.

APPENDIX B. Data File Format

B.1 Hole Data File Format

```

***
GK 604M(v1.0.1.0,01/13);2.0;FORMAT II
PROJECT :myHoles
HOLE NO. :newHole
DATE    :01/02/13
TIME    :14:32:13
PROBE NO.:testProbe
FILE NAME:newHole_001.gkn
#READINGS:61
FLEVEL,      A+,      A-,      B+,      B-
30.0, 1013, -1052, -380, 320
29.5, 945, -985, -377, 315
29.0, 946, -981, -346, 290
28.5, 945, -978, -331, 276
28.0, 995, -1048, -337, 278
27.5, 1014, -1050, -318, 263
27.0, 1034, -1068, -316, 265
26.5, 1046, -1078, -348, 288
26.0, 1037, -1075, -376, 326
25.5, 1042, -1075, -415, 366
25.0, 1079, -1116, -430, 366
24.5, 1053, -1087, -440, 378
24.0, 1027, -1066, -449, 385
23.5, 1024, -1061, -477, 413
23.0, 1020, -1054, -474, 422
22.5, 1029, -1063, -500, 448
22.0, 1099, -1131, -485, 437
21.5, 1080, -1116, -503, 439
21.0, 1047, -1082, -514, 462
20.5, 1043, -1075, -518, 454
20.0, 1042, -1077, -527, 469
19.5, 1062, -1096, -542, 480
19.0, 1074, -1105, -551, 487
18.5, 1085, -1118, -553, 490
18.0, 1104, -1140, -572, 513
17.5, 1097, -1128, -541, 483
17.0, 1090, -1125, -549, 500
16.5, 1069, -1105, -545, 493
16.0, 1103, -1139, -567, 497
15.5, 1082, -1129, -566, 506
15.0, 1065, -1100, -553, 495
14.5, 1052, -1086, -529, 467
14.0, 1009, -1045, -519, 452
13.5, 956, -991, -534, 468
13.0, 899, -933, -558, 492
12.5, 841, -874, -557, 493
12.0, 800, -836, -568, 499
11.5, 778, -808, -547, 482
11.0, 755, -789, -522, 464
10.5, 752, -785, -489, 440
10.0, 754, -789, -465, 409
9.5, 766, -802, -433, 378
9.0, 769, -804, -429, 371
8.5, 765, -800, -435, 372
8.0, 762, -795, -442, 379

```

7.5,	785,	-819,	-441,	386
7.0,	811,	-844,	-456,	388
6.5,	809,	-842,	-450,	394
6.0,	802,	-837,	-472,	414
5.5,	786,	-817,	-464,	398
5.0,	776,	-809,	-475,	412
4.5,	788,	-818,	-468,	404
4.0,	777,	-808,	-447,	381
3.5,	707,	-757,	-435,	375
3.0,	707,	-739,	-408,	354
2.5,	686,	-721,	-407,	359
2.0,	647,	-680,	-413,	356
1.5,	608,	-643,	-412,	357
1.0,	559,	-599,	-359,	298
0.5,	564,	-600,	-361,	300
0.0,	565,	-600,	-359,	300

APPENDIX C. Text Reports

C.1 Raw Data Text Report

Hole Survey Raw Data Report

 Project Name: myHoles
 Hole Name: newHole
 Top Elevation: 186.6

File Name: newHole_001.gkn
 Reading Date: 01/02/13
 Reading Time: 14:32:13
 Probe Name: testProbe

Level (m)	A+ (dig.)	A- (dig.)	B+ (dig.)	B- (dig.)	Elev. (m)
0.5	564	-600	-361	300	186.1
1	559	-599	-359	298	185.6
1.5	608	-643	-412	357	185.1
2	647	-680	-413	356	184.6
2.5	686	-721	-407	359	184.1
3	707	-739	-408	354	183.6
3.5	707	-757	-435	375	183.1
4	777	-808	-447	381	182.6
4.5	788	-818	-468	404	182.1
5	776	-809	-475	412	181.6
5.5	786	-817	-464	398	181.1
6	802	-837	-472	414	180.6
6.5	809	-842	-450	394	180.1
7	811	-844	-456	388	179.6
7.5	785	-819	-441	386	179.1
8	762	-795	-442	379	178.6
8.5	765	-800	-435	372	178.1
9	769	-804	-429	371	177.6
9.5	766	-802	-433	378	177.1
10	754	-789	-465	409	176.6
10.5	752	-785	-489	440	176.1
11	755	-789	-522	464	175.6
11.5	778	-808	-547	482	175.1
12	800	-836	-568	499	174.6
12.5	841	-874	-557	493	174.1
13	899	-933	-558	492	173.6
13.5	956	-991	-534	468	173.1
14	1009	-1045	-519	452	172.6
14.5	1052	-1086	-529	467	172.1
15	1065	-1100	-553	495	171.6
15.5	1082	-1129	-566	506	171.1
16	1103	-1139	-567	497	170.6
16.5	1069	-1105	-545	493	170.1
17	1090	-1125	-549	500	169.6
17.5	1097	-1128	-541	483	169.1
18	1104	-1140	-572	513	168.6
18.5	1085	-1118	-553	490	168.1
19	1074	-1105	-551	487	167.6
19.5	1062	-1096	-542	480	167.1
20	1042	-1077	-527	469	166.6
20.5	1043	-1075	-518	454	166.1
21	1047	-1082	-514	462	165.6
21.5	1080	-1116	-503	439	165.1
22	1099	-1131	-485	437	164.6
22.5	1029	-1063	-500	448	164.1
23	1020	-1054	-474	422	163.6
23.5	1024	-1061	-477	413	163.1
24	1027	-1066	-449	385	162.6
24.5	1053	-1087	-440	378	162.1
25	1079	-1116	-430	366	161.6

25.5	1042	-1075	-415	366	161.1
26	1037	-1075	-376	326	160.6
26.5	1046	-1078	-348	288	160.1
27	1034	-1068	-316	265	159.6
27.5	1014	-1050	-318	263	159.1
28	995	-1048	-337	278	158.6
28.5	945	-978	-331	276	158.1
29	946	-981	-346	290	157.6
29.5	945	-985	-377	315	157.1
30	1013	-1052	-380	320	156.6

C.2 A-axis Profile Data Text Report

Report: A-Axis Digits and Profile in Centimeters (Bottom Up)

 Project Name: myHoles
 Hole Name: newHole
 Top Elevation: 186.6
 Azimuth Angle: 0.0

File Name: newHole_001.gkn
 Reading Date: 01/02/13
 Reading Time: 14:32:13
 Probe Name: testProbe

Elev (m)	A+ (dig.)	A- (dig.)	Sum (dig.)	Diff (dig.)	Diff/2 (dig.)	Defl (cm)	Level (m)
186.1	564	-600	-36	1164	582	139.79	0.5
185.6	559	-599	-40	1158	579	138.34	1
185.1	608	-643	-35	1251	626	136.89	1.5
184.6	647	-680	-33	1327	664	135.33	2
184.1	686	-721	-35	1407	704	133.67	2.5
183.6	707	-739	-32	1446	723	131.91	3
183.1	707	-757	-50	1464	732	130.10	3.5
182.6	777	-808	-31	1585	793	128.27	4
182.1	788	-818	-30	1606	803	126.29	4.5
181.6	776	-809	-33	1585	793	124.28	5
181.1	786	-817	-31	1603	802	122.30	5.5
180.6	802	-837	-35	1639	820	120.30	6
180.1	809	-842	-33	1651	826	118.25	6.5
179.6	811	-844	-33	1655	828	116.19	7
179.1	785	-819	-34	1604	802	114.12	7.5
178.6	762	-795	-33	1557	779	112.11	8
178.1	765	-800	-35	1565	783	110.17	8.5
177.6	769	-804	-35	1573	787	108.21	9
177.1	766	-802	-36	1568	784	106.24	9.5
176.6	754	-789	-35	1543	772	104.28	10
176.1	752	-785	-33	1537	769	102.35	10.5
175.6	755	-789	-34	1544	772	100.43	11
175.1	778	-808	-30	1586	793	98.50	11.5
174.6	800	-836	-36	1636	818	96.52	12
174.1	841	-874	-33	1715	858	94.48	12.5
173.6	899	-933	-34	1832	916	92.33	13
173.1	956	-991	-35	1947	974	90.04	13.5
172.6	1009	-1045	-36	2054	1027	87.61	14
172.1	1052	-1086	-34	2138	1069	85.04	14.5
171.6	1065	-1100	-35	2165	1083	82.37	15
171.1	1082	-1129	-47	2211	1106	79.66	15.5
170.6	1103	-1139	-36	2242	1121	76.90	16
170.1	1069	-1105	-36	2174	1087	74.10	16.5
169.6	1090	-1125	-35	2215	1108	71.38	17
169.1	1097	-1128	-31	2225	1113	68.61	17.5
168.6	1104	-1140	-36	2244	1122	65.83	18
168.1	1085	-1118	-33	2203	1102	63.02	18.5
167.6	1074	-1105	-31	2179	1090	60.27	19
167.1	1062	-1096	-34	2158	1079	57.55	19.5
166.6	1042	-1077	-35	2119	1060	54.85	20
166.1	1043	-1075	-32	2118	1059	52.20	20.5

165.6	1047	-1082	-35	2129	1065	49.55	21
165.1	1080	-1116	-36	2196	1098	46.89	21.5
164.6	1099	-1131	-32	2230	1115	44.15	22
164.1	1029	-1063	-34	2092	1046	41.36	22.5
163.6	1020	-1054	-34	2074	1037	38.74	23
163.1	1024	-1061	-37	2085	1043	36.15	23.5
162.6	1027	-1066	-39	2093	1047	33.54	24
162.1	1053	-1087	-34	2140	1070	30.93	24.5
161.6	1079	-1116	-37	2195	1098	28.25	25
161.1	1042	-1075	-33	2117	1059	25.51	25.5
160.6	1037	-1075	-38	2112	1056	22.86	26
160.1	1046	-1078	-32	2124	1062	20.22	26.5
159.6	1034	-1068	-34	2102	1051	17.57	27
159.1	1014	-1050	-36	2064	1032	14.94	27.5
158.6	995	-1048	-53	2043	1022	12.36	28
158.1	945	-978	-33	1923	962	9.81	28.5
157.6	946	-981	-35	1927	964	7.40	29
157.1	945	-985	-40	1930	965	4.99	29.5
156.6	1013	-1052	-39	2065	1033	2.58	30

Average Channel A Offset: -17.5

C.3 B-axis Profile Data Text Report

Report: B-Axis Digits and Profile in Centimeters (Bottom Up)

 Project Name: myHoles
 Hole Name: newHole
 Top Elevation: 186.6
 Azimuth Angle: 0.0

File Name: newHole_001.gkn
 Reading Date: 01/02/13
 Reading Time: 14:32:13
 Probe Name: testProbe

Elev (m)	B+ (dig.)	B- (dig.)	Sum (dig.)	Diff (dig.)	Diff/2 (dig.)	Defl (cm)	Level (m)
186.1	-361	300	-61	-661	-330	-65.30	0.5
185.6	-359	298	-61	-657	-328	-64.48	1
185.1	-412	357	-55	-769	-384	-63.65	1.5
184.6	-413	356	-57	-769	-384	-62.69	2
184.1	-407	359	-48	-766	-383	-61.73	2.5
183.6	-408	354	-54	-762	-381	-60.77	3
183.1	-435	375	-60	-810	-405	-59.82	3.5
182.6	-447	381	-66	-828	-414	-58.81	4
182.1	-468	404	-64	-872	-436	-57.77	4.5
181.6	-475	412	-63	-887	-443	-56.68	5
181.1	-464	398	-66	-862	-431	-55.58	5.5
180.6	-472	414	-58	-886	-443	-54.50	6
180.1	-450	394	-56	-844	-422	-53.39	6.5
179.6	-456	388	-68	-844	-422	-52.34	7
179.1	-441	386	-55	-827	-413	-51.28	7.5
178.6	-442	379	-63	-821	-410	-50.25	8
178.1	-435	372	-63	-807	-403	-49.22	8.5
177.6	-429	371	-58	-800	-400	-48.21	9
177.1	-433	378	-55	-811	-405	-47.21	9.5
176.6	-465	409	-56	-874	-437	-46.20	10
176.1	-489	440	-49	-929	-464	-45.11	10.5
175.6	-522	464	-58	-986	-493	-43.94	11
175.1	-547	482	-65	-1029	-514	-42.71	11.5
174.6	-568	499	-69	-1067	-533	-41.43	12
174.1	-557	493	-64	-1050	-525	-40.09	12.5
173.6	-558	492	-66	-1050	-525	-38.78	13
173.1	-534	468	-66	-1002	-501	-37.47	13.5
172.6	-519	452	-67	-971	-485	-36.21	14
172.1	-529	467	-62	-996	-498	-35.00	14.5
171.6	-553	495	-58	-1048	-524	-33.76	15

171.1	-566	506	-60	-1072	-536	-32.45	15.5
170.6	-567	497	-70	-1064	-532	-31.11	16
170.1	-545	493	-52	-1038	-519	-29.78	16.5
169.6	-549	500	-49	-1049	-524	-28.48	17
169.1	-541	483	-58	-1024	-512	-27.17	17.5
168.6	-572	513	-59	-1085	-542	-25.89	18
168.1	-553	490	-63	-1043	-521	-24.53	18.5
167.6	-551	487	-64	-1038	-519	-23.23	19
167.1	-542	480	-62	-1022	-511	-21.93	19.5
166.6	-527	469	-58	-996	-498	-20.65	20
166.1	-518	454	-64	-972	-486	-19.41	20.5
165.6	-514	462	-52	-976	-488	-18.19	21
165.1	-503	439	-64	-942	-471	-16.97	21.5
164.6	-485	437	-48	-922	-461	-15.79	22
164.1	-500	448	-52	-948	-474	-14.64	22.5
163.6	-474	422	-52	-896	-448	-13.46	23
163.1	-477	413	-64	-890	-445	-12.34	23.5
162.6	-449	385	-64	-834	-417	-11.22	24
162.1	-440	378	-62	-818	-409	-10.18	24.5
161.6	-430	366	-64	-796	-398	-9.16	25
161.1	-415	366	-49	-781	-390	-8.16	25.5
160.6	-376	326	-50	-702	-351	-7.19	26
160.1	-348	288	-60	-636	-318	-6.31	26.5
159.6	-316	265	-51	-581	-290	-5.52	27
159.1	-318	263	-55	-581	-290	-4.79	27.5
158.6	-337	278	-59	-615	-307	-4.06	28
158.1	-331	276	-55	-607	-303	-3.29	28.5
157.6	-346	290	-56	-636	-318	-2.54	29
157.1	-377	315	-62	-692	-346	-1.74	29.5
156.6	-380	320	-60	-700	-350	-.88	30

Average Channel B Offset: -29.6

C.4 A-axis Deflection Data Text Report

Report: A-Axis Change in Digits and Deflection in Centimeters (Bottom Up)

```

-----
Project Name: myHoles
Hole Name: newHole
Top Elevation: 186.6
Azimuth Angle: 0.0
-----
--Initial Data--      --Current Data--
File Name: newHole_001.gkn  newHole_002.gkn
Reading Date: 01/02/13      01/03/13
Reading Time: 14:32:13      13:54:50
Probe Name: testProbe      testProbe
-----
Elev.    --Initial (digits)--  --Current (digits)--  Corr.  Defl.  Level
(m)      A+      A-      Diff.  A+      A-      Diff.  Diff.  (cm)  (m)
-----
186.1    564    -600    1164    508    -657    1165    1      -.09   0.5
185.6    559    -599    1158    510    -656    1166    8      -.09   1
185.1    608    -643    1251    541    -698    1239   -12     -.10   1.5
184.6    647    -680    1327    591    -736    1327    0      -.08   2
184.1    686    -721    1407    631    -776    1407    0      -.08   2.5
183.6    707    -739    1446    650    -796    1446    0      -.08   3
183.1    707    -757    1464    666    -809    1475   11      -.08   3.5
182.6    777    -808    1585    719    -865    1584   -1      -.10   4
182.1    788    -818    1606    728    -874    1602   -4      -.09   4.5
181.6    776    -809    1585    719    -865    1584   -1      -.09   5
181.1    786    -817    1603    730    -873    1603    0      -.09   5.5
180.6    802    -837    1639    747    -893    1640    1      -.09   6
180.1    809    -842    1651    753    -898    1651    0      -.09   6.5
179.6    811    -844    1655    755    -898    1653   -2      -.09   7
179.1    785    -819    1604    729    -874    1603   -1      -.09   7.5
178.6    762    -795    1557    706    -851    1557    0      -.09   8
178.1    765    -800    1565    710    -855    1565    0      -.09   8.5
177.6    769    -804    1573    714    -859    1573    0      -.09   9

```

177.1	766	-802	1568	711	-857	1568	0	-.09	9.5
176.6	754	-789	1543	699	-845	1544	1	-.09	10
176.1	752	-785	1537	682	-840	1522	-15	-.09	10.5
175.6	755	-789	1544	698	-844	1542	-2	-.07	11
175.1	778	-808	1586	720	-865	1585	-1	-.07	11.5
174.6	800	-836	1636	746	-892	1638	2	-.06	12
174.1	841	-874	1715	782	-929	1711	-4	-.07	12.5
173.6	899	-933	1832	843	-989	1832	0	-.06	13
173.1	956	-991	1947	900	-1047	1947	0	-.06	13.5
172.6	1009	-1045	2054	931	-1100	2031	-23	-.06	14
172.1	1052	-1086	2138	996	-1142	2138	0	-.03	14.5
171.6	1065	-1100	2165	1008	-1156	2164	-1	-.03	15
171.1	1082	-1129	2211	1038	-1185	2223	12	-.03	15.5
170.6	1103	-1139	2242	1046	-1193	2239	-3	-.05	16
170.1	1069	-1105	2174	1014	-1161	2175	1	-.04	16.5
169.6	1090	-1125	2215	1034	-1180	2214	-1	-.04	17
169.1	1097	-1128	2225	1041	-1184	2225	0	-.04	17.5
168.6	1104	-1140	2244	1048	-1196	2244	0	-.04	18
168.1	1085	-1118	2203	1029	-1174	2203	0	-.04	18.5
167.6	1074	-1105	2179	1019	-1164	2183	4	-.04	19
167.1	1062	-1096	2158	1006	-1150	2156	-2	-.05	19.5
166.6	1042	-1077	2119	985	-1133	2118	-1	-.05	20
166.1	1043	-1075	2118	987	-1131	2118	0	-.04	20.5
165.6	1047	-1082	2129	991	-1138	2129	0	-.04	21
165.1	1080	-1116	2196	1025	-1171	2196	0	-.04	21.5
164.6	1099	-1131	2230	1041	-1187	2228	-2	-.04	22
164.1	1029	-1063	2092	974	-1119	2093	1	-.04	22.5
163.6	1020	-1054	2074	965	-1110	2075	1	-.04	23
163.1	1024	-1061	2085	969	-1117	2086	1	-.04	23.5
162.6	1027	-1066	2093	972	-1119	2091	-2	-.05	24
162.1	1053	-1087	2140	998	-1143	2141	1	-.04	24.5
161.6	1079	-1116	2195	1023	-1171	2194	-1	-.04	25
161.1	1042	-1075	2117	985	-1131	2116	-1	-.04	25.5
160.6	1037	-1075	2112	982	-1130	2112	0	-.04	26
160.1	1046	-1078	2124	989	-1134	2123	-1	-.04	26.5
159.6	1034	-1068	2102	977	-1125	2102	0	-.04	27
159.1	1014	-1050	2064	958	-1105	2063	-1	-.04	27.5
158.6	995	-1048	2043	937	-1093	2030	-13	-.04	28
158.1	945	-978	1923	889	-1022	1911	-12	-.02	28.5
157.6	946	-981	1927	888	-1037	1925	-2	-.01	29
157.1	945	-985	1930	889	-1039	1928	-2	-.01	29.5
156.6	1013	-1052	2065	956	-1107	2063	-2	.00	30

C.5 B-axis Deflection Data Text Report

Report: B-Axis Change in Digits and Deflection in Centimeters (Bottom Up)

 Project Name: myHoles
 Hole Name: newHole
 Top Elevation: 186.6
 Azimuth Angle: 0.0

--Initial Data--	--Current Data--
File Name: newHole_001.gkn	newHole_002.gkn
Reading Date: 01/02/13	01/03/13
Reading Time: 14:32:13	13:54:50
Probe Name: testProbe	testProbe

Elev. (m)	--Initial (digits)--			--Current (digits)--			Corr. Diff.	Defl. (cm)	Level (m)
	B+	B-	Diff.	B+	B-	Diff.			
186.1	-361	300	-661	-361	300	-661	0	.05	0.5
185.6	-359	298	-657	-361	300	-661	-4	.05	1
185.1	-412	357	-769	-413	358	-771	-2	.06	1.5
184.6	-413	356	-769	-412	355	-767	2	.06	2
184.1	-407	359	-766	-412	357	-769	-3	.06	2.5
183.6	-408	354	-762	-408	356	-764	-2	.06	3

183.1	-435	375	-810	-434	376	-810	0	.07	3.5
182.6	-447	381	-828	-447	382	-829	-1	.07	4
182.1	-468	404	-872	-468	404	-872	0	.07	4.5
181.6	-475	412	-887	-474	411	-885	2	.07	5
181.1	-464	398	-862	-464	406	-870	-8	.06	5.5
180.6	-472	414	-886	-469	411	-880	6	.07	6
180.1	-450	394	-844	-450	393	-843	1	.07	6.5
179.6	-456	388	-844	-454	386	-840	4	.07	7
179.1	-441	386	-827	-437	379	-816	11	.06	7.5
178.6	-442	379	-821	-442	378	-820	1	.05	8
178.1	-435	372	-807	-435	371	-806	1	.05	8.5
177.6	-429	371	-800	-430	369	-799	1	.04	9
177.1	-433	378	-811	-438	376	-814	-3	.04	9.5
176.6	-465	409	-874	-464	408	-872	2	.05	10
176.1	-489	440	-929	-489	439	-928	1	.04	10.5
175.6	-522	464	-986	-523	460	-983	3	.04	11
175.1	-547	482	-1029	-546	481	-1027	2	.04	11.5
174.6	-568	499	-1067	-566	502	-1068	-1	.04	12
174.1	-557	493	-1050	-557	494	-1051	-1	.04	12.5
173.6	-558	492	-1050	-557	491	-1048	2	.04	13
173.1	-534	468	-1002	-533	470	-1003	-1	.04	13.5
172.6	-519	452	-971	-519	451	-970	1	.04	14
172.1	-529	467	-996	-526	468	-994	2	.04	14.5
171.6	-553	495	-1048	-554	496	-1050	-2	.03	15
171.1	-566	506	-1072	-564	505	-1069	3	.04	15.5
170.6	-567	497	-1064	-566	508	-1074	-10	.03	16
170.1	-545	493	-1038	-540	492	-1032	6	.05	16.5
169.6	-549	500	-1049	-551	499	-1050	-1	.04	17
169.1	-541	483	-1024	-540	481	-1021	3	.04	17.5
168.6	-572	513	-1085	-571	513	-1084	1	.04	18
168.1	-553	490	-1043	-553	491	-1044	-1	.03	18.5
167.6	-551	487	-1038	-550	487	-1037	1	.04	19
167.1	-542	480	-1022	-541	481	-1022	0	.03	19.5
166.6	-527	469	-996	-529	469	-998	-2	.03	20
166.1	-518	454	-972	-517	454	-971	1	.04	20.5
165.6	-514	462	-976	-513	449	-962	14	.04	21
165.1	-503	439	-942	-502	439	-941	1	.02	21.5
164.6	-485	437	-922	-486	437	-923	-1	.02	22
164.1	-500	448	-948	-499	447	-946	2	.02	22.5
163.6	-474	422	-896	-475	422	-897	-1	.02	23
163.1	-477	413	-890	-476	414	-890	0	.02	23.5
162.6	-449	385	-834	-448	384	-832	2	.02	24
162.1	-440	378	-818	-440	377	-817	1	.01	24.5
161.6	-430	366	-796	-423	364	-787	9	.01	25
161.1	-415	366	-781	-416	366	-782	-1	.00	25.5
160.6	-376	326	-702	-377	324	-701	1	.00	26
160.1	-348	288	-636	-349	290	-639	-3	.00	26.5
159.6	-316	265	-581	-316	266	-582	-1	.01	27
159.1	-318	263	-581	-316	263	-579	2	.01	27.5
158.6	-337	278	-615	-338	275	-613	2	.00	28
158.1	-331	276	-607	-329	272	-601	6	.00	28.5
157.6	-346	290	-636	-350	293	-643	-7	-.01	29
157.1	-377	315	-692	-377	315	-692	0	.00	29.5
156.6	-380	320	-700	-379	319	-698	2	.00	30

APPENDIX D. Remote Module Command Structure

COMMAND	FUNCTION	SYNTAX	RETURN VALUE
0	TAKE VA READING	0	(+/-)####
1	TAKE VB READING	1	(+/-)####
2	TAKE BATTERY READING	2	<sp><sp>+#. #
3	TAKE -12V READING ¹	3	<sp>-12.0
4	FIRMWARE VERSION ⁴	4	VER#. #
5	(see Note 2)	5	<CR>
6	(see Note 2)	6	000<sp><sp><sp>
7	TAKE +12V READING ¹	7	<sp>+12.0
8	TAKE +5V REFERENCE READING	8	<sp><sp>+#. #
9	TAKE 3.3V READING ¹	9	<sp><sp>+3.3
D	LOAD PROBE DEFAULTS ³	D	See Example D
G	DISPLAY GAGE PARAMETERS ³	G	See Example G2
G	ENTER GAGE PARAMETERS ³	G70A/(LorP)/#/#/# or G70B/(LorP)/#/#/# See example G below	See Example G1
T	PROBE TEMPERATURE (°C) ³	T	(+/-)###.###
V	FIRMWARE VERSION (Remote Module) ³	V	VER#. #
#	DISPLAY PROBE SERIAL # ³	#	See example #
#sn	ENTER PROBE SERIAL # ³	#sn(16 alphanumeric characters or symbols)	See example #sn

Notes:

1. These commands exist only for GK-604 analog systems and are included in the digital system for compatibility.
2. Like Note 1 but are for internal use only.
3. These commands exist only for GK-604D digital system.
4. Firmware Version (Command 4) returns the Remote Module version for analog systems and the probe firmware version for digital systems.

Example 1: LOAD PROBE DEFAULTS

Loads probe default gage parameters (calibration factors):

Command: D<CR>

Response: GT:70A ZR:0.0000 GF:1.0000 GO:0.0000 GT:70B ZR:0.0000 GF:1.0000 GO:0.0000

Channels VA and VB: Linear Conversion
Zero Read Offset = 0
Gage Factor = 1
Gage Offset = 0

Results in digits display = 2000(Vout)

Example 2: Enter Gage Parameters:

Enter and store gage parameters for each axis:

A axis: Linear conversion
 Zero Read Offset = 0
 Gage Factor = .62
 Gage Offset = 0

Command: G70A/L/0/.62/0<CR>

Response: GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.0000 GO:0.0000

B axis: Linear conversion
 Zero Read Offset = 0
 Gage Factor = 1.005
 Gage Offset = 0

Command: G70B/L/0/1.005/0<CR>

Response: GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.005 GO:0.0000

Example 3: Display Gage Parameters:

Display gage parameters stored in the probe:

Command: G<CR>

Response: GT:70A ZR:0.0000 GF:0.6200 GO:0.0000 GT:70B ZR:0.0000 GF:1.005 GO:0.0000

Example 4: Display Probe Serial Number:

Display the serial number that is stored in the probe:

Command: #<CR>

Response: 6001-E,126543

Example 5: Enter Probe Serial Number:

Enter and store probe serial number. Up to 16 alphanumeric characters and symbols may be stored.

Command: #sn6001-E,126543<CR>

Response: 6001-E,126543 ⁽¹⁾

NOTES:

1. The GK-604D IRA uses the serial number to determine the appropriate probe units (metric or english) by reading the model number portion of the serial number string (the part to the left of the comma). If the model number does not contain a “-E” or a “-M” then unpredictable results may occur.

APPENDIX E. Data Reduction Formulas

E.1. Deflection Calculation

Label	Description															
ZZ	Correction Angle (usually 0°).															
RINT	Absolute Reading Interval in feet or meters.															
IA+,IA−	Initial A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).															
PA+,PA−	Present A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).															
IB+,IB−	Initial B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).															
PB+,PB−	Present B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).															
SA	Calculated Digit Change for A Axis.															
SB	Calculated Digit Change for B Axis.															
M	<table><tr><td>Multiplier, where:</td><td>Geokon probe</td><td>Sinco Probe</td></tr><tr><td>Probe configuration</td><td>2sinθ,</td><td>2.5sinθ.</td></tr><tr><td>Metric units, millimeters,</td><td>0.05</td><td>0.04</td></tr><tr><td>Metric units, centimeters,</td><td>0.005</td><td>0.004.</td></tr><tr><td>Imperial units, inches</td><td>0.0006</td><td>0.00048</td></tr></table>	Multiplier, where:	Geokon probe	Sinco Probe	Probe configuration	2sinθ,	2.5sinθ.	Metric units, millimeters,	0.05	0.04	Metric units, centimeters,	0.005	0.004.	Imperial units, inches	0.0006	0.00048
Multiplier, where:	Geokon probe	Sinco Probe														
Probe configuration	2sinθ,	2.5sinθ.														
Metric units, millimeters,	0.05	0.04														
Metric units, centimeters,	0.005	0.004.														
Imperial units, inches	0.0006	0.00048														
CA	Deflection A (in inches, English units, not corrected). Deflection A (in centimeters or millimeters, Metric units, not corrected).															
CB	Deflection B (in inches, English units, not corrected). Deflection B (in centimeters or millimeters, Metric units, not corrected).															
DA	Deflection A (in inches, English units, corrected for angle). Deflection A (in centimeters or millimeters, Metric units, corrected for angle).															
DB	Deflection B (in inches, English units, corrected for angle). Deflection B (in centimeters or millimeters, Metric units, corrected for angle).															
cos	Cosine function.															
sin	Sine function .															

Table E-1 Data Reduction Variables (Deflection)

$$SA = ((PA+) - (PA-))/2 - ((IA+) - (IA-))/2$$

$$SB = ((PB+) - (PB-))/2 - ((IB+) - (IB-))/2$$

Equation E-1 Change in Digits Calculation (Deflection)

$$CA = M \times RINT \times SA$$

$$CB = M \times RINT \times SB$$

$$DA = (CA \times \cos(ZZ)) - (CB \times \sin(ZZ))$$

$$DB = (CA \times \sin(ZZ)) + (CB \times \cos(ZZ))$$

Equation E-2 Deflection Calculation

Note: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the deflection change (Figure 63).

E.2. Profile Calculation

Label	Description														
ZZ	Correction Angle (usually 0°).														
RINT	Absolute Reading Interval in feet or meters.														
A+, A–	A Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).														
B+, B–	B Axis Data in Digits (2sinθ=10000 @ 30°, 2.5sinθ=12500 @ 30°).														
SA	Calculated Digit Change for A Axis.														
SB	Calculated Digit Change for B Axis.														
M	Multiplier, where: <table><tr><td>Geokon probe</td><td>Sinco Probe</td></tr><tr><td>Probe configuration</td><td>2sinθ,</td><td>2.5sinθ.</td></tr><tr><td>Metric units, millimeters,</td><td>0.05</td><td>0.04</td></tr><tr><td>Metric units, centimeters,</td><td>0.005</td><td>0.004.</td></tr><tr><td>Imperial units, inches</td><td>0.0006</td><td>0.00048</td></tr></table>	Geokon probe	Sinco Probe	Probe configuration	2sinθ,	2.5sinθ.	Metric units, millimeters,	0.05	0.04	Metric units, centimeters,	0.005	0.004.	Imperial units, inches	0.0006	0.00048
Geokon probe	Sinco Probe														
Probe configuration	2sinθ,	2.5sinθ.													
Metric units, millimeters,	0.05	0.04													
Metric units, centimeters,	0.005	0.004.													
Imperial units, inches	0.0006	0.00048													
CA	Deflection A (in inches, English units, not corrected). Deflection A (in centimeters or millimeters, Metric units, not corrected).														
CB	Deflection B (in inches, English units, not corrected). Deflection B (in centimeters or millimeters, Metric units, not corrected).														
DA	Deflection A (in inches, English units, corrected for angle). Deflection A (in centimeters or millimeters, Metric units, corrected for angle).														
DB	Deflection B (in inches, English units, corrected for angle). Deflection B (in centimeters or millimeters, Metric units, corrected for angle).														
cos	Cosine function.														
sin	Sine function .														

Table E-2 Data Reduction Variables (Profile)

$$SA = ((A+) - (A-)) / 2$$

$$SB = ((B+) - (B-)) / 2$$

Equation E-3 Change in Digits Calculation (Profile)

$$CA = M \times RINT \times SA$$

$$CB = M \times RINT \times SB$$

$$DA = (CA \times \cos(ZZ)) - (CB \times \sin(ZZ))$$

$$DB = (CA \times \sin(ZZ)) + (CB \times \cos(ZZ))$$

Equation E-4 Profile Calculation

Note: Accumulate (Σ) DA and DB results at each depth increment (from the bottom up or the top down) to obtain the profile.

E.3. GTILT Users

When using GTILT with the GK-604D use a Probe Constant of 10000 for both English and Metric probes when using 2.0sin Units! For 2.5sin Units use a Probe Constant of 12500.

APPENDIX F. Technical Specifications

F.1. GK-604D Digital System Specifications

Standard Range	$\pm 30^\circ$
Sensors	2 MEMS accelerometers
MEMS Output	Differential ± 4 VDC
6100D Probe Output	Digital Data Stream
Probe Resolution	24-bit
System Resolution ¹	± 0.025 mm/500 mm (± 0.0001 ft/2 ft)
Accuracy	$\pm 0.05\%$ Full Scale (F.S.)
Linearity	$\pm 0.02\%$ F.S., up to $\pm 10^\circ$
Repeatability	± 1 mm/30 m
Total System Accuracy ²	± 3 mm/30 m (± 0.125 in/100 ft)
Temperature Range (Probe)	0°C to 50°C
Temperature Range (Remote Module)	-30°C to 50°C
Temperature Coefficient	0.002% F.S./°C
Wheel Base	0.5 m, 1m or 2 ft
Length x Diameter ³	700 x 25 mm, 1200 x 25 mm or 32 x 1 in
Casing Size I.D. ⁴	51 to 89 mm (2.0 to 3.5 in)
Weight (with case)	7.5 kg (16 lb)
Shock Survival ⁵	2000 g
Battery (Remote Module)	Li-Ion, 7.4 V, 2600 mAh; >40 hours continuous operation per charge

Notes:

1. ± 10 arc seconds. This resolution is true only in the range of $\pm 5^\circ$ from vertical. Beyond this, the resolution is diminished by the cosine of the angle from vertical.
2. Within 3° of vertical. This takes into account the accumulation of the error inherent with each reading and normal placement errors in positioning the probe inside the casing; also the effect of debris in the casing or casing damage.
3. The cable connector adds 150 mm to the length of the probe. The wheel diameter is 30mm.
4. The probe is designed for use in all standard inclinometer casing up to a maximum diameter of 89 mm (3.5 inches).
5. The Inclinometer Probe is a highly sensitive device and should be treated with great care at all times in order to maintain calibration. In particular, the probe should be prevented from impacting the bottom of the casing with any force.

F.2. Analog Probe System Specifications

The following table contains specifications for the analog probe system which is comprised of a probe (6100-1M or 6100-1E) and the Remote Module. The Remote Module can be either a GK-604-3 (reel system) or a GK-604-4 (probe interface).

Probe Range (100% F.S.)	$\pm 30^\circ$
Remote Module Input Range	± 8 VDC
Sensors	2 MEMS accelerometers
MEMS Output ¹	± 4 VDC
Probe Resolution ²	.025 mm /500mm (.0001 ft/ 2 ft)
Remote Module Resolution	16 bit
Repeatability ³	± 1 mm/30m (± 0.05 in/100ft)
Total System Accuracy ⁴	± 4 mm/ 30 m (± 0.17 inch/ 100 ft)
Remote Module Accuracy	$\pm 0.1\%$ F.S.
Probe Temperature Range	-20°C to 50°C (-4° to 122°F)
Remote Module Temp. Range	-30°C to 50°C
Temperature Coefficient	$<.0002\%$ F.S./ $^\circ\text{C}$ ($<.0002\%$ F.S./ $^\circ\text{F}$)
Wheel Base	0.5m or 1.0m (2 ft)
Probe Length x Diameter ⁵	700 x 25 mm dia. (32 x 1 in dia.)
GK-604-3 Dimensions	(L x W x H): 380 x 280 x 490 mm
GK-604-4 Dimensions	(L x W x H): 160 x 75 x 75 mm
Weight (with case) (GK-604-1)	7.5 kg (16 lb)
Shock Survival	2000g
Battery (Remote Module)	Li-Ion, 7.4 V, 2600 mAh; >16 hours continuous operation per charge

Notes:

1. The probe outputs ± 4 volts at an inclination of $\pm 30^\circ$ to the vertical. These parameters are referred to as full scale. Operation beyond this inclination is not possible with a standard MEMS probe.
2. The resolution shown in the table above is only true in the range of $\pm 5^\circ$ from the vertical. Beyond this the resolution is reduced by a factor equal to $1/\cos$ of the angle from the vertical. For instance the resolution at 0 degrees from vertical is 10.3 arc seconds and the resolution at 15 degrees from the vertical is $10.3 \times 1/0.966 = 10.7$ arc seconds. The figures given assume that the readout box can detect a change of output of 0.0005 VDC.
3. The figure shown applies to the use of a single probe used repeatedly over a short space of time in a single borehole.
4. In practice, system accuracy is controlled mainly by the precision with which the inclinometer can be positioned at exactly the same depth, in the casing, from survey to survey. Factors such as debris in the casing or casing damage also have an effect. The stated accuracy assumes that the surveys are conducted over a period of time in a proper manner and that the casing is within 5 degrees off the vertical. Accuracy is

improved by allowing the probe to reach equilibrium at each depth level before taking a reading.

5. The probe is designed for use in all casing sizes up to 85mm ID (3.34in.). The wheel diameter is 30mm. The cable connector adds 150mm to the length of the probe.

F.3. Field PC (GK-604-6) Specifications

Processor	520 MHz PXA270
Operating System	Windows Mobile® 6.1 Classic
Included Software	Microsoft® Office Mobile; multiple languages
Memory	128 MB RAM
Data Storage	512 MB internal data storage; compact Flash slot (Type I or II); SD/SDHC slot; SDIO supported; user accessible CF and SD slots
Color Display	89 mm QVGA (240 x 320) active viewing area; High visibility active matrix TFT transfective back-lit LCD
Keyboard	Four-way directional button; discrete keys for Start, Applications, Manager, Home, Context Menu, Return and Power/Suspend; some key functions can be user-defined; LED back-lit keys
Ports	COM1, RS-232C 9-pin "D" connector with 5VDC at 200 mA power out available on DTR pin; USB Host (Mini A); USB Client (Mini B); 12 VDC @ 800 mA power in, 10 – 18 V unregulated; communications module is user replaceable
Case	Magnesium with scratch resistant powder coat; easy to grip, impact absorbing overmold; IP67 waterproof
Environmental	Tested to MIL-STD810F for water, humidity, sand, dust vibration, altitude, shock and temperature
Power	Intelligent 3900 mAh Li-Ion battery; operates for up to 20 hours on one charge; charges in 4 to 6 hours; battery easily changed in the field without tools
Wireless Connectivity	Internal Bluetooth® wireless technology option, 2.0 +EDR, Class 1, range 20 m
Wi-Fi Support	SDIO or CF Wi-Fi card required
Certification & Standards	FCC Class B; CE Mark; EN60950; RoHS compliant; FM approved Class I, Div 2
Operating Temperature	-30°C to 55°C
Storage Temperature	-30°C to 60°C
Shock Survival	Multiple drops from 1.5 m onto concrete
Dimensions	(L x W x H): 165 x 89 x 43 mm
Weight	482 g, with battery